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THE BEGINNINGS OF COUNTING.

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In the mind of civilized man as he exists today, the concept of number is one of the most familiar of the concepts of daily life. Number is used with the utmost frequency, beginning at an age so early that all remembrance of its origin is lost in the mists of childhood, and continuing, in constant use, down to the last day of our existence. The notion becomes so familiar, so much a part of daily routine, that, except in the case of those engaged in its special study, all perception of number as a distinctive idea is entirely lost; and we give to it no more actual thought than we do to the retina of the eye, upon which the material things of the world picture themselves. Much less do we stop to consider the beginnings of counting, the first perception, wholly unconscious, of course, that there really is such a thing as number.

But the study of this question is of more than passing interest; and some attempt has been made by the writer to examine the origin and to trace the development of the number idea as it appears in the history of human progress. Both physically and mentally, the life of each human being is, in epitome, the life of the human race as a whole; and a study of the development, throughout recorded time, of the number idea as it is seen in the race, is the best possible preparation for a sympathetic understanding of the growth of that idea in the mind of the individual child.

We have no means of ascertaining definitely whether the cardinal numerals precede the ordinals in point of mental development, or whether the ordinals are the first to be awarded distinct recognition. Logical argument has been advanced in favor of the claims for priority on behalf of each class, but the weight of evidence appears to be decidedly in favor of the cardinals.

The first perception of number enters the human mind the moment the child recognizes the fact that two objects are more than one object, and that the two are distinct from each other. Of any clear perception of number the intellect is still quite unconscious; but the number concept begins here, and the moment increase is recognized as resulting from the association of one object with another object, in distinction from mere enlargement of size, the beginning of counting appears.

Number in itself is a purely abstract idea, but the considerations just adduced show clearly that this fact is one which obtains recognition only at a comparatively late stage of mental development. It is at the outset used only in connection with concrete ideas, which are, from the very nature of things, of the simplest possible character. The thought is directed toward the fact that there are two *sticks,* for example, rather than the fact that there are *two* sticks. The objects themselves, and not the mere number of them, fill up the mind. In this sense, the beginnings of counting belong to a stage of development so elementary that it may fairly be said to belong, not only to the most immature members of the human race, but also to the higher orders of the brute creation. Many animals seem to possess a well defined idea of the difference between one and two, and also a notion, much less distinct it must be admitted, but still a notion, of the difference between two and three, and three and four.

In this connection the following quotation from Sir John Lubbock deserves the most thoughtful consideration: "A man was anxious to shoot a crow. To deceive this suspicious bird, the plan was hit upon of sending two men to the watchhouse, one of whom passed on, while the other remained; but the crow counted, and kept her distance. The next day three went, and again she perceived that only two retired. In fine, it was necessary to send five or six men to the watchhouse to put her out in her calculation. The crow, thinking that this number of men had passed by, lost no time in returning. From this he inferred that crows could count up to four. Lichtenberg mentions a nightengale which was said to count up to three. Every day he gave it three meal worms, one at a time. When it had finished one it returned for another, but after the third it knew the feast was over. * * * There is an amusing and suggestive remark in Mr. Galton's *Narrative of an Explorer in Tropical South Africa.*

After describing the Demara's weakness in calculations, he says: Once while I watched a Demara floundering hopelessly in a calculation on one side of me, I observed Dinah, my spaniel, equally embarrassed on the other. She was overlooking half a dozen of her new-born puppies, which had been removed two or three times from her, and her anxiety was excessive, as she tried to find out if they were all present, or if any were still missing. She kept puzzling and running her eyes over them backwards and forwards, but could not satisfy herself. She evidently had a vague notion of counting, but the figure was too large for her brain. Taking the two as they stood, dog and Demara, the comparison reflected no great honor on the man. According to my bird nesting recollections, which I have refreshed by more recent experiences, if a nest contains four eggs, one may safely be taken; but if two are removed the bird generally deserts. Here, then, it would seem as if we had some reason for supposing that there is sufficient intelligence to distinguish three from four. An interesting consideration arises with reference to the number of victims allotted to each cell of the solitary wasps. One species of *ammophila* considers one large caterpillar of *noctura segetum* enough; one species of *eumenes* supplies its young with five victims; another ten, fifteen, and even up to twenty-four. The number appears to be constant in each species. How does the insect know when her task is fulfilled? Not by the cell being filled, for if some be removed, she does not replace them. When she has brought her complement she considers her task accomplished, whether the victims are still there or not. How, then, does she know when she has made up the number twenty-four? Perhaps it will be said that each species feels some mysterious and innate tendency to provide a certain number of victims. This would, under no circumstances, be any explanation; but it is not in accordance with the facts. In the genus *eumenes* the males are much smaller than the females. * * * If the egg is male, she supplies five; if female, two victims. Does she count? Certainly this seems very like a commencement of arithmetic."

A careful study of this question of the origin of number can lead to no other logical conclusion except the one which Lubbock has here set forth so clearly; that is, that the number sense as it appears in primitive man is not in any marked degree different from the same perception in the case of the higher animals. With

this conclusion many writers do not agree, maintaining that there is, in all cases of apparent animal perception of number, simply a perception of greater or less quantity, and no idea whatever of number. But such arguments are not convincing. In a consideration of this question which has now extended over many years, the writer has never yet had brought to his attention any argument against the possession by the higher animals of a rudimentary number sense which would not apply with equal force to many of the primitive races of mankind, and also to the child which has just reached that stage of mental development which enables him to comprehend the difference between one and two.

In this connection it may be well to illustrate by a few examples, the rudimentary condition of the number sense among primitive peoples; and to show by that means how slight is the difference in this one particular between the intelligence of the savage and the intelligence of the most highly developed of the brute creation. There is no recorded instance of a tribe where the idea of number was wholly absent; but as we descend in the scale of intelligence we find that the ability to comprehend this idea, or, to put the matter differently, we find that the ability to count, diminishes rapidly. A point is finally reached where the ability to count seems to disappear altogether, and the entire numeral system, if so dignified a term may here be used, consists of the two words *one* and *many,* or the three words *one, two, many.* Going lower still, we find certain tribes, like the Chiquitos of Bolivia, where the only trace of a number word is the equivalent for the word *alone.* Here the vanishing point of the number sense is reached; and here the intelligence of the animal may fairly be said to overlap the intelligence of the human being.

The most rudimentary number scales that have ever been recorded by explorers have been found among the native races of South America and Australia. In South America we may cite as illustrations the Encabellada, whose only numerals are *tey,* 1, *cayapa,* 2; the Mbocobi, with *yña tvak,* 1, *yñoaca,* 2; the Puris with *omi,* 1, *curiri,* 2, *prica,* many; and the Botocudos, with *mokenam,* 1, *uruhu,* many. These are taken almost at random, and are given merely to show the actual extent of the savages's perception of number. Instance after instance of a similar nature might be given; and the count of South American, Australian, and

Tasmanian tribes which yield numeral lists no more extensive than those that have just been instanced, is a very long one.

The mental poverty of a human being who can make no use of number except as it is indicated by the words *one, many,* or *one, two, many,* is at first not easy to understand. But this is due solely to the fact that number has, from earliest childhood, been one of the most familiar concepts of our daily existence. It is one of the fundamentals of modern civilization, and to it we give no more thought than we do to the fact that we wear clothing. But with the savage it is different. Into his daily life the need for any except the most limited number ideas never enters. He learns to distinguish one from two, and perhaps two from three; and that for him is enough. Anything greater than that is always more or less vague in his mind, and, no matter what the number actually is, it is designated by the same word; *many, heap,* and *plenty* being among the most common terms thus employed.

It is only when this condition of barbarism has been passed, and the next stage reached in the development of the race that counting really begins; and it is most interesting to observe that it is now almost always accompanied by some artificial aid. The difference between one and two is clearly understood by the primitive mind; and, as has already been pointed out, the perception of this difference marks the beginning of the number sense. But an attempt to express with any degree of definiteness the next numbers beyond this limit, three, four, etc., results in instant confusion, and the resort is at once had to counters of some kind for the purpose of aiding the mind in its attempt to grasp this new and larger total. These counters are in the great majority of cases the fingers of one, or perhaps of both hands. They are the natural counters, and so convenient have they proved to be that their use has continued through all the stages of civilization through which the race has passed, and they are today the familiar counters of the most highly developed races of the world. Their use has resulted in fastening upon modern arithmetic the universal number system of which ten is the base—a fact to be deplored, because ten is as a number base decidedly inferior to twelve. If the human race had been provided with twelve fingers instead of ten, the mathematical work of the world would have been done by means of a duodecimal number system instead of a decimal. But

when the number of fingers was made five for each hand, the arithmetic of mankind was fixed forever on a decimal base.

As long as the savage remains content with but two numerals he felt little need of any words with which to express his idea of them; and his terms for one and two can hardly be said to have been pure numerals. Any two objects would be in his mind simply "this" and "that." Indeed, there is reason to believe that, in certain languages, the original meanings of the numerals used to designate one and two were precisely those to be found in the words here mentioned. But when any attempt is made to proceed further, the need of numeral terms is at once felt, and the formation of the numeral nomenclature of the language begins. Now and then a case is met with in which the finger origin, the most common of all origins for numeral words, is seen from the very beginning of the count, where one is expressed by some word for finger, and two by some rude paraphrase for double finger. But usually it is impossible to trace the meaning of the very earliest of the numerals of a language.

From a large number of lists the following have been selected as presenting typical examples of the formation of a number scale. The meanings of the various words render superfluous any attempt at explanation, and show with perfect clearness the working of the primitive mind as he passed from one stage to the next. The first is the number scale of the Zuñi Indians, which is as follows:

1. töpinte = taken to start with,
2. kwilli = put down together with,
3. ha'i = the equally dividing finger,
4. awite = all the fingers all but done with,
5. öpte = the notched off,
6. topalīk'ya = another brought to add to the done with,
7. kwillilik'ya = two brought to and held up with the rest,
8. hailik'ye = three brought to and held up with the rest,
9. tenalik'ya = all but all are held up with the rest,
10. ästem'thila = all the fingers,
11. ästem'thla topayä'thl'tona = all the fingers and another above held,

20. kwillik'yènästem'thlan = two times all the fingers,

100. ässäistem'thlak'ya = the fingers all the fingers, etc.

The other scale is that of the Montagnais tribe of Indians of Northern Canada, whose method of progression was the following:

1. inl'are = the end is bent,
2. nak'e = another is bent,
3. t'are = the middle is bent,
4. dinri = there are no more except this,
5. se-sunla-re = the row on the hand,
6. elkke-t'are = three from each side,
7. { t'a-ye-oyertan = there are still three of them,
   inl'as dinri = on one side there are four of them,
8. elkke dinri = four on each side,
9. inl'a-ye-oyert'an = there is still one more,
10. onernan = finished on each side,
11. onernan inl'are ttcharidhel = one complete and one,
12. onernan nak'e ttcharidhel = one complete and two, etc.

Both of these lists are valuable from the fact that they enable us to follow the origin of the words back to the very beginning of numeration, as well as to trace the successive steps in the formation of the systems. Each shows the unmistakable finger-origin of counting, and also the inevitable tendency toward the selection of ten as a base. And yet this statement, confidently as it is made, requires a certain degree of modification. Counting as he does, the savage, on reaching five, says "one hand," "all the fingers on one hand," or by some equivalent expression signifies that he has completed the number which can be indicated in this manner. At ten he says "both hands," or "one man," and at twenty, having completed the tale of counters which nature has placed at his disposal, he says "hands and feet," "all the fingers and toes," "two times all the fingers," or "one man." Though by no means universal, these names for five, ten and twenty are exceedingly common in all parts of the world. Also, the words for six, seven, etc., are the equivalents for "hand one," "hand two," or "one on the other hand," "two on the other hand," etc.; and for eleven, twelve, etc., we find "one on the foot," "two on the foot," or "all the fingers and one more," "all the fingers and two more," etc. These numeral terms, and indeed the method as a whole, show at once that, while ten is a natural number base, five is an equally natural number to serve the same purpose, and twenty also is a total which might readily serve as a point for fresh departure. While ten is the

number of fingers on both hands, five is the number on one hand; and it is the natural number at which the first pause is made. Five is "one hand," in very many languages, and the progression "hand one, hand two, hand three," etc., shows the natural use of five as the base upon which counting was carried on. But no such system ever proceeded far without relegating five to a subordinate position, and assuming ten or twenty as its principal base. The latter number is certainly too large to form a convenient base, and it is a matter of some surprise that the quinary should in so many cases merge into the vigesimal rather than the decimal system.

The vigesimal system is never found entirely pure. Examination always shows the presence of either the quinary or the decimal system subordinate to it. Among the native races of America the quinary-vigesimal system is the one of most frequent occurrence, though sometimes a trace of the decimal is also found. The elaborate Aztec system is the most perfect known example of a vigesimal system, but it contained both the quinary and the decimal scales, subordinate to the vigesimal. A similar statement applies to every other system ever recorded, which is built up with the use of twenty as a base.

For some unexplained reason vigesimal, or more properly, quinary-vigesimal number systems are rare in the Old World. The only modern example of it to be found in Europe is the Basque system. Some of the native tribes of Siberia and of the Caucasus reckon by twenties, but elsewhere it is rare. In America it has been found to be more common among the native races than the decimal mode of counting, and the study of these Indian and Eskimo scales is full of interest. But it is a noteworthy fact that in ancient times this mode of counting was common in many parts of Europe. The Phoenicians, and presumably the Carthagenians, reckoned by twenties, and through contact with them the Celtic nations of Western Europe became familiarized with this method of counting; and abundant traces of it are found in their languages. The Bretons still say "unnek ha trigent," that is "eleven and three twenties," for seventy-one. The French say "quatre vignt" for eighty, and from that point to 100 they count by a pure vigesimal scale, as far as the names of their numbers are concerned. The Welsh, the Erse, the Gaelic, the Manx and other Celtic races show in their languages similar traces of a former use of the vigesimal base. Traces of a similar nature may also be

found among the Teutonic languages, but they are infrequent, and indicate but little. A hundred consisting of 120 and known as the "great hundred," or "long hundred," was formerly in use in England, which was legal for certain articles. That its use was common is attested by the popular old distich

> Five score of men, money, and pins,
> Six score of all other things.

The very word "score," and a few happily preserved expressions such as "three score and ten," show that an unconscious flavor of the vigesimal had made its way into the reckoning used by our ancestors. The Danish, and other Teutonic languages, contain words and expressions which indicate that the same was true of others of the peoples of Northern Europe. Here, however, the application seems always to have been to material objects rather than to pure number; and the Teutonic number-systems cannot be said ever to have been vigesimal. But the naturalness of this method of counting is emphasized anew by the fact that it forced its way into the material dealings of races whose systems were otherwise purely decimal, and there gained a permanent foothold.

But, however great the number of examples may be of races that have used or now use the quinary or the vigesimal scale, the fact remains that by far the greatest number of uncivilized peoples perform their reckoning by tens; and that, with a meager list of exceptions, all civilized peoples have done and now do the same. With one single exception, the decimal scale is universal in Europe. It is almost universal in Africa; in Polynasia the same is true; in Asia all the civilized, and the great majority of the uncivilized races, count with the use of this base; in North America it has been found among many of the native races; and in South America it was sometimes used, though the prevailing system was either quinary or quinary-vigesimal. The simple, and undoubtedly the correct explanation of the origin of this system, is the laying aside of a counter or the scoring of a mark, on the completion of each tale of ten on the fingers. This develops into a perfect decimal system, and needs only the introduction of characters, or symbols, to develop into a written number system like the Roman or the Chinese; or, with the aid of place-value, into the Hindu system, which is that of the modern civilized world. As a number base, ten is preferable to either five or twenty; and no

number scale could better serve the purpose of mankind than the decimal, with the single exception of the duodecimal. But the advantage of twelve as a base never becomes apparent until the arithmetic of a people has reached such a degree of development that a change from one system to the other would be attended with difficulties so great as to render it quite impracticable. Civilization is wedded to the decimal arithmetic; and though it may buy and sell by dozens and perform its astronomical calculations by sixties, it will always continue to use the arithmetic of tens in preference to any other. All other methods of computation give way, sooner or later, before the decimal; just as all other systems of weights and measures must ultimately yield and disappear before the metric system.

A MINOR REFORM.

By G. A. Miller.

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In the Hindu notation of numbers the higher units always precede the lower. This is in accord with the almost universal law, first observed by Hankel, that in the additive combination of numbers the larger precedes the smaller.* In numeration we observe the same law except for the nine numbers between ten and twenty. Instead of saying ty-one, ty-two, ty-three, ty-four, ty-five, ty-six, ty-seven, ty-eight, ty-nine, we say eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen, respectively. Why should we say thirteen when we do not say three-twenty or three-thirty?

The matter looks worse when it is observed that in numeration the smaller units before the larger always signify multiplication with the exception of the numeration of the nine numbers mentioned above. Thirteen means three-ten just as thirty does. Should such ambiguity be tolerated when the remedy is so simple? If we should adopt nine words like those suggested above we would have a rational, consistent numeration at least up to 10,000.

The difficulties in the way of adopting these nine number words instead of those in vogue are slight when compared with those encountered in the change of the base of notation, or even in the

* Cf. Cantor Geschichte der Mathematik, 1894, p. 14.

change from the ordinary system of weights and measures to the metric system. It would involve nothing more than the learning of nine closely related words. No tables would have to be reconstructed nor would any books become useless by their adoption.

While the difficulties in the way of this minor reform seem slight compared with those in the way of other reforms just mentioned, it must be admitted that the advantages resulting from its adoption would also be very much smaller. The question is whether the advantages are sufficient to justify the slight difficulties. Does consistency and uniformity appeal sufficiently to our ethical nature to pay attention to this matter which lies at the threshold of the education of every child?

As Taylor has aptly remarked, "The case is not uncommon of high civilization bearing evident traces of the rudeness of its origin in ancient barbaric life." Do we want to wipe away another one of these traces or are we anxious to be continually reminded of our past? If the change is to be made it requires agitators and adherents in large numbers. It seems to be merely a question as to whether the time is ripe for this work; for, as culture advances more refined elements of progress receive attention.

The English speaking people could perfect their numeration with more ease than the German, since in the latter language the smaller precedes the larger in additive combination up to 100. For instance, the Germans say three and twenty, four and ninety instead of twenty-three, ninety-four, respectively. They would therefore have to employ eighty-one new number words whereas we would need only nine to effect this reform. The French, on the contrary, use the words ten-seven, ten-eight, ten-nine for seventeen, eighteen, nineteen, respectively, but they employ some other irregular number words, such as sixty-sixteen for seventy-six, four-twenty-thirteen for ninety-three.

It seems that reform is also desirable in the numeration of large numbers. The fact that we should have separate names for each order of units up to the third and then employ separate names for every third order thereafter can scarcely be justified. However, these numbers occur seldom and do not enter very largely into the education of the child, and hence reform along this line is not so imperative.

IS THE TREATMENT OF THE THEORY OF LIMITS IN OUR ELEMENTARY GEOMETRIES LOGICAL? *

By Alan Sanders.

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Our early American geometries, which were largely translations from the French, followed the plan of Legendre and *assumed,* without any proof, that the circle was the limit of inscribed, or of circumscribed, regular polygons when the number of sides is indefinitely increased.

The modern treatment of the theory of limits was introduced into our later geometries to supply a proof for this assumption. The only excuse then for the introduction of the doctrine of limits into elementary geometry is that it was to give a satisfactory proof for the proposition quoted above, and for the analogous proposition in solid geometry relating to cylinder, cone and sphere.

The proofs of the propositions of plane geometry in which the theory of limits is used in our American geometries is fairly logical, but what is given as proofs in the analogous propositions of solid geometry are no proofs at all, but assumptions pure and simple, as were those of Legendre.

Before discussing these proofs, let me say that I showed a list of the geometries that I had examined on this subject to an official of a prominent text book publishing company, and asked him what proportion of the geometries used in the United States was represented there.

He said: "You have here all the *prominent* geometries published in this country. There are a number of geometries which do not appear on your list, but they are what we call *local books*—books of small circulation, used only in restricted localities. Your list represents ninety per cent of the geometries sold in this country."

In view of this statement I will affirm that ninety per cent of the boys and girls of this country who are studying geometry are, in their solid geometry, studying demonstrations whose logic is vile. I am referring to those propositions of solid geometry in which the theory of limits is used.

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*From the opening address to the Association of Ohio Teachers of Mathematics and Science at their meeting in Columbus, Dec. 29, 1904.

Take the following as an example: "If a prism whose base is a regular polygon is inscribed in a circular cylinder, and if the number of the sides of the base is indefinitely increased, the volume of the prism approaches the volume of the cylinder as its limit, and the lateral surface of the prism approaches the lateral surface of the cylinder as its limit."

The proof given (stripped of its verbiage) is: "Since the circumference of the base of the cylinder is the limit of the perimeter of the base of the prism, and the area of the base of the cylinder is the limit of the area of the base of the prism, *therefore* the volume of the cylinder is the limit of the volume of the prism, and the lateral surface of the cylinder is the limit of the lateral surface of the prism."

This is, of course, the baldest kind of an assumption. When it was proved in plane geometry that the circumference was the limit of the perimeter of an inscribed polygon, nothing was proved about *position* or *shape* of the perimeter. The term limit as used in mathematics has nothing to do with position or shape. The definition states that the limit of a variable is a constant from which the variable can be made to differ by less than any assignable quantity. The perimeter cannot differ from the circumference in *position* or *shape* by less than any assignable *quantity*. All that has been proved in that proposition is that the *length* of the broken line forming the perimeter can be made to differ from the *length* of the curved line forming the circumference by less than any assignable quantity.

To state without proof in solid geometry that the volume of that irregular solid lying between the lateral surfaces of the cylinder and inscribed prism, a solid for whose volume we have no expression up to this point—to state, I repeat, that the volume of this solid can be made less than any assignable quantity because its base can be made less than any assignable quantity, *is an assumption.*

To state without proof that the lateral surface of the cylinder, a surface for whose area there is no expression up to this point, is the limit of the lateral surface of the inscribed prism, because the perimeter of the base of the prism can be made to differ from the circumference of the base of the cylinder by less than any assignable quantity, is another assumption as bad as the former.

The only assumptions admissable in a logical geometry are axioms and postulates. The foregoing assumptions being capable of proof are not axiomatic.

In only two geometries of my list was there even an attempt made to prove this assumption.

In one of these the proof given for the proposition relating to the cylinder is wrong. The author fails to note that a right section of an oblique circular cylinder is an ellipse, and that proposition relating to circles, cannot be used as authorities here. The corresponding proposition relating to cone and sphere are also wrong.

In the other, after stating the propositions in the same manner that all the others do, the author adds a foot note after each one: "For a vigorous proof of this proposition, see my appendix."

But unfortunately several of the *"rigorous proofs"* in the appendix contain the same vicious assumption that spoiled the demonstrations of all the books of the list.

The fact that ninety per cent of the geometries used in this country give no proof for the propositions quoted relating to cylinder, cone and sphere, is a matter worthy of the serious consideration of the teachers of geometry.

GRAPH TRACING.

By F. C. Boon,
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Teachers unfamiliar with elementary analytical geometry may be glad to know a more organized way of dealing with graph tracing than mere plotting of points, and teachers who are mathematicians to learn that such methods may be used without difficulty in ordinary algebraical teaching for young pupils. My experience is that boys can be led to trace curves with more certainty and with an understanding of the aims of graph tracing.

In the case of an *equation of the first degree* it might be demonstrated:

(1) That if the equation is put in the form $y = mx + c$, m determines its direction and c its actual position. Thus, in the case of $5y = 3x + c$, if any value of x is increased by 5, the corresponding value of y is increased by 3, and so, if a series of points, A, B, C, D, etc., be found in this way, AB, BC, CD, etc.,

will be hypothenuses of right-angled triangles whose sides are 3 and 5 units; whence AB, BC, CD, etc., are shown to be in *the same straight line, whose direction* is determined *by the ratio* 3/5.

If A, the first point, had been taken on the axis of Y for some special value of c, then, if c were given different values, A would occupy different positions on the axis, but B, C and D would have the same position relative to A as before.

(2) That, in particular, if $c = 0$, the line passes through the origin. And in general for any function of x and y in which the absolute term is zero, if $x = 0$, then a value of y is obtained, also $= 0$, *i. e.*, the graph passes through the origin.

(3) That $y = mx + c$ and $y_2 = mx + c_2$ make equal angles with the axes.

(4) That $y = mx + c$ and $y = -\frac{1}{m}x + c_2$ are at right angles.

3 and 4 may be shown by the same method as No. 1.

It should be insisted on that an equation of the first degree is a straight line, and that it is only necessary to plot two points in order to trace the graph.

For the *equation of the second degree* I have found it advisable to treat typical curves in their simple forms.

(1) $x^2 = y$, parabola.

y cannot be negative; positive and negative values of the same numerical value of x give only one value of y, no greater limits to x or y. Therefore the curve is symmetrical about the axis of y, is above the axis of x touching it (since the origin is on the curve, and since when $y = 0$, $x^2 = 0$ gives two coincident values of x, each $= 0$), and goes to affinity in the positive direction.

(2) $xy = c$, hyperbola.

x and y must have the same sign; if $x = a$, $y = b$ satisfies it, then $x = -a$, $y = -b$ also satisfies it. Therefore there are two branches of the curve precisely equal and similarly situated, but in opposite quadrants (first and third); also no limits to x or y, but as x increases y decreases, and so on.

(3) $x^2 + y^2 = r^2$, circle.

The equation is at once deducible from the definition of a circle.

It is symmetrical about both axes, since a substitution of $-x$ for x or $-y$ for y leaves the equation unaltered, x and y

must each lie between $(\pm)\ r$, and so for (4) $9x^2-16y^2=144$, hyperbola, and (5) $9x^2+16y^2=144$, ellipse.

Now, if the curve be moved bodily b units along the axis of Y and a units along the axis of X, equations (1), (2) and (3) become

$(x-a)^2=(y-b)$, having the axis $x-a=0$, and vertex a, b.

$(x-a)\ (y-b)=c$, having the asymptotes $x-a=0$, $y-b=0$.

$(x-a)^2+(y-b)^2=r^2$, having the centre a, b and

And, whenever an equation can be redueed to one of these forms, it is reduced to a standard form, and its nature, position and some other facts are at once known.

Thus to trace (1) $x^2-4x+7=y$.

This curve is used for the geometrical solution of a quadratic equation; it may be treated suitably, therefore, by the method used for solving a general quadratic:

$$x^2-4x=y-7.$$
$$x^2-4x+4=y-3.$$
$$(x-2)^2=y-3.$$

The graph is a parabola, having an axis $x-2=0$; vertex 2, 3; minimum value of $y=3$; and coincident values of $x=2$.

(2) $xy-3x+4y=2$.

$(x+4)\ (y-3)=2-12=10$.

The curve is an hyperbola in the second and fourth quadrants formed by the lines $x+4=0$ and $y-3=0$.

(3) $x^2+y^2-2x+4y=0$.

$x^2-2x+y^2+4y=0$.

$x^2-2x+1+y^2+4y+4=1+4$.

$(x-1)^2+(y+2)^2=5$.

The graph is a circle whose centre is 1, -2 and radius $=\sqrt{5}$. But it is simpler in practice to trace the curve by noticing that it passes through the origin than by trying to measure $\sqrt{5}$.

It is often possible to demonstrate clearly the nature of an asymptote by showing first that terms of the first degree and the absolute term are negligible in comparison with terms of the second degree, if x and y are infinitely great. Thus the terms of the second degree give the shape of the curve at infinity, and if the terms of the second degree have (α) real factors, the curve goes to infinity in two directions; (β) coincident factors, the

cruve goes to infinity in two coincident directions; (γ) imaginary factors, the curve does not go to infinity. Thus (α) is the condition for a hyperbola, or its limiting position is two straight lines; (β) is the condition for a parabola; (γ) is the condition for a closed curve, *i. e.*, an ellipse or its special case—a circle.

It is still necessary to plot points in the case of all curves but the circle; but one has the advantage of knowing what to expect, where to begin to plot, *e. g.*, from the vertex in the case of the parabola, the asymptotes in cases of an hyperbola and the axes of the ellipse in the case of an ellipse.—*School World.*

PRACTICAL SUGGESTIONS AS TO WAYS OF IMPROVING THE MATHEMATICAL OUTPUT OF SECONDARY SCHOOLS.

By J. J. Shobinger.
The Harvard School, Chicago.

We have heard of late so much about poor teaching in mathematics and the better results they get elsewhere that one might easily get the impression that all our mathematical instruction until now has been bad. I want to protest against this. They do things differently abroad; their aims are different, in some respects, and their results are better, in some respects, than ours, but not in all. Our system of concentration, with only three or four studies carried at one time, with heavy home lessons, and one recitation every day, produces a degree of skill in operation, a readiness and quickness in execution that the German student, for instance (and essentially the same system prevails over the continent) never gets. They begin with geometry, take up algebra later, then carry the two along together for several years, each with but a few recitations a week. This system correlates the two domains, but it does not beget skill and readiness. I can testify from my own experience that when I came to this country and saw the examination papers set by the colleges and the time in which they expected them to be done, I was amazed, and I know perfectly well that I couldn't have done them at the same stage of my education in that time. I have it from mathematics professors at this university* that have had the experience of both systems, that they find in this readiness and quickness which the

* The University of Chicago.

American system begets a distinct point in our favor. So that they, on the other side, sacrifice something while securing certain results that seem important to them, while we sacrifice something in securing the results just mentioned.

What is it we are sacrificing? In the first place, we place the subjects in clean, logical separation, one after the other. I think it unfortunate that the almost universal consensus leads us to begin with algebra, because algebra is so entirely formal and has so little real and material content. Geometry begun first would furnish us with much material to use in algebra. But as it is, we go first through one year of algebra. Then the college gives us our first unit in mathematics. We now lay that subject aside and take up geometry. The American is very logical, and he satisfies this need to the full. We disregard every other aspect except the strictly logical proofs, wait learning the erection of perpendiculars, bisecting of angles, till we have completed the book of the circle, learn computing circumference and area of circle at the very end of plain geometry, and all through are content to slapdash our figures on, without regard to truth, learning the logical proofs very well, indeed, but nothing else, and all the time completely ignoring the algebra of the year before. Then the university gives us another unit of credit in mathematics. During the third year algebra and the solid geometry, and then we get our third unit.

Now this is all wrong. The student never learns the real meaning of algebra, because it is mostly juggling with symbols that mean nothing. If ever any science had its origin in practical needs it is algebra. Whoever has given attention to the history of mathematics knows that the algebraic processes were invented as fast and as far as they would solve problems. As a new problem arose that would not yield to the means at hand, the master invented new processes that would accomplish his purpose. Gradually, as students were taught certain difficulties of operation that persisted to recur were gathered into chapters, and practiced by themselves, so that they might no longer delay the real work and this was finally carried to the exaggerated length in which we find it now, where we are losing sight of the end through much study of processes.

In geometry it is much the same thing. Our treatment of it is extremely one-sided. We must abate much of the logical

severity of the sequence of propositions, emphasize practical familiarity with the figures by accurate drawing of all of them, in propositions, problems and exercises in construction, and we must apply our algebra vigorously in the study of the numerical relations to be found in the figures.

I had an illustration that will show you what I mean. A year ago my daughter attended the École Supérieure in Lausanne. They have there a weak course in geometry, two recitations a week. This sounds ridiculous to us, but they don't believe there that girls need so much mathematics as the boys. Naturally, I didn't expect much. Yet I was surprised one day to find the following problem given to the girls for a home lesson.

Given: a square; four quadrants drawn with the vertices of the squares as centers and the half-sides as radii; a small circle touching the four quadrants. Compute the area of the surface between the circular arcs. Give that to your boys and girls some day and note results. What was most surprising to me was that most of the girls there got it.

As we do things we learn arithmetic and formal algebra, and the logic of geometry, but we do not learn mathematics. We can hardly touch a practical problem that does not require the application of two, or all three of these subjects; and only if all three are at his mental fingers' ends, does the student know mathematics?

Now I charge the college with much responsibility for this condition of things. The system of mathematical requirements fosters it, and if it did not exist, would produce it. It is hard to realize to what an extent the college dominates our aims and methods. This inference is especially direct with us in the college preparatory school, but it is no less real in the city high schools. For, though a majority of your students do not go to colleges, you *must* prepare those that do go, as the college wants them prepared, and besides, you come from colleges, and we all like to "swear by the words of the master."

Look into any of the algebra examination papers and you will find seven or eight examples dealing with transformations and literal equations, and then quite at the bottom, shamefacedly, one solitary problem. Students generally get that far and then the time is up and they are glad it is. I have never heard of any student that was conditioned because he hadn't done the problem.

I wish the colleges would reverse matters, put in five or six problems, and two or three examples involving manipulation purely and simply. A professor to whom I once said this answered: "Why, if we did that we couldn't pass a single paper." I am by no means so sure of this. I think the schools are quick to follow when a real improvement is suggested. When fifteen years ago Harvard proclaimed the new requirements in physics and chemistry, as illustrated by Professor Cook's and Professor Hall's pamphlets, the schools stood aghast. Why, we can never do that! But one school followed, and another, and then more, and found the gain was great and immediate, and now there is not a high school that could even conceive the possibility of going back to methods in vogue only fifteen years ago.

I am confident the same thing would occur if the college undertook to call upon us for *mathematics,* instead of algebra and geometry.

I wish the college would let us earn our three units in this wise: (1) An easy paper containing problems calling for applications of arithmetic, algebra and geometry; this constituting the first unit. (2) A harder paper of the same nature, with constructions—problems to be carefully performed with ruler and compass, for second unit. (3) A third paper, involving solid geometry, with computating work leading to quadratics, also specific gravity, and some other simple laws of physics for third unit.

Let this requirement be made and there will be rustling among the dry bones. When required to teach *mathematics,* I think it will turn out that ways will be found that lead to mathematics as results, instead of three separate neat little drawers as we now have them of goods that nobody wants, and goods that the possessors do not know what to do with.

We shall never, I believe, do this in the German way, though I hope we may come to beginning with geometry, instead of with algebra. But we must find a way to make constant use of the subject completed in the next subject we take up, and I am glad to acknowledge that much of what we are hearing of late is admirably adapted to help us in this.

One thing yet as to the mathematics called for in physics. While it is true that physics is a mathematical science, and that no law is established till it can be formulated mathematically, there is for the beginner a host of facts that are unknown to him

and that he must become familiar with before they can be mathematically related. There are whole chapters of which the students know nothing at all, others in which all the information they have is malinformation. This has to be uprooted and new ideas planted and made familiar by experiments that had many times best not be quantitive, and so may easily begin with mathematics too early, and thus build in the air. Then again: some chapters, such as dynamics, are of such supreme importance that they should be studied carefully and well, and the mathematics in them fully mastered. Others of slighter importance may with impunity be omitted, provided those fundamental relations are well understood. Provided the relations between velocity, distance, time, force, acceleration, energy, are mastered, I consider the formulas for vibrating strings or rods, and even the formula for the pendulum of small importance. Here also, I think Harvard has shown much greater wisdom than any other college that has taken physics as one of its requirements.

I think that with these limitations the mathematical outfit called for by physics is small in extent. What is most needed is *the ability to discern mathematical relations, and to translate them into mathematical, i. e., algebraic language.*

A formula that cannot, at the high school stage, be derived so as to appear to the student perfectly reasonable should be postponed and left to the college. Suppose I want to derive the formula for the relation between force, mass, velocity and time. To do this I need first, by pulling a car loaded with more or less weight by means of a spring or a rubberband, to make perfectly clear the following facts: To give a greater velocity in a given time, the force must be greater; to give the same velocity to a larger mass, the force must be greater; to give the same velocity in a longer time, the force must be smaller. Next, I tell the student that a force cannot be observed directly, but only by the effects it produces, and that as the most convenient effect has been selected *the velocity the force gives to the body in one second.* So if a force gives to a mass of one pound a velocity of one foot, it is called 1, or the unit force. If it is to give to a mass of four pounds the same velocity, it must be four times as large, or 4×1. If now it is to give that mass a velocity of not one foot, but three feet, it must again be three times as large, or $1\times4\times3$. If, now, that velocity is to be given in a time of not one second, but five seconds,

it may be 1/5 as large; that is $\frac{1\times4\times3}{5}$. By varying these numbers, it is noticed that formulas of the same form are obtained, and then the students are prepared to admit as true the final formula

$$f=\frac{mv}{t}$$

Every important formula should be made plain in this way, by reasoning it out, not once for all, but repeatedly, until the student gets over the idea of magic that seems to surround these physics formulas and until they appear to him plain common sense.

I consider this very important. I have never in all my teaching attached so much importance to covering the whole ground as to covering that fraction I could cover (if I had to be satisfied with a fraction) *thoroughly*. For in the latter case the student has a foundation upon which later work can be built. Covering the ground leaves the novitiate in a situation in which, figuratively, he does not know his right hand from his left and is ready to admit almost anything as possible as the most direct means of escape. This is the condition of affairs that drives the next teacher to despair.

SOME EXPERIENCES IN LABORATORY MATHEMATICS AND THEIR RESULTS.

By Franklin Turner Jones,
University School, Cleveland, Ohio.

Essentially a physics teacher, the writer, since his first teaching, has appreciated keenly the shortcomings of his pupils in mathematics and has observed their inability to apply the knowledge they were supposed to possess to the working of problems. The agitation over improved mathematics teaching and possible correlation between physics and mathematics naturally appeals very strongly as a possible remedy.

This problem has been very ably attacked by many teachers, especially in the West, and an outline of laboratory experiments in Plane Geometry, by Plant and Bishop of Bradley Polytechnic Institute, was published as Appendix III of the Proceedings of the Second Annual Meeting of the Central Association of Science and Mathematics Teachers. In the same publication many valua-

ble suggestions and helpful hints are given toward the development of correlated courses.

Using this outline as a basis, I tried physics laboratory experiments with a class of boys in geometry corresponding to second year High School pupils. Contrary to my expectation and desire, the attempt to use these experiments could not be considered a success. Among the experiments tried were the following:

1. Comparison of the inch and centimeter.
2. Law of reflection—Angle of incidence is equal to the angle of reflection.
3. Center of gravity of a triangle.
4. Law of refraction.

After spending some time on such experiments with indifferent success, I changed my mode of operation and introduced the use of squared or cross-section paper. This was suggested by Prof. John Perry's articles and his syllabus as published in the "Discussion on the Teaching of Mathematics" (Macmillan); also in Castle's books on Practical Mathematics (Macmillan). The experiments, or rather problems, solved by the use of squared paper were the, *a,* plotting of straight lines as $x + y = 6$, $x + y = 12$, $x - y = 3$, etc., etc.; of circles as $x^2 + y^2 = 9$, of ellipses as $\frac{x^2}{9} + \frac{y^2}{16} = 1$, etc.; *b,* the solution of simple simultaneous equations of the first and second degree by plotting and observing their intersections; *c,* finding the areas of figures by counting squares enclosed and therefrom deducing rules for computing areas.

The success of these analytic geometry problems was such that I shall try the same or similar experiments again. They were satisfactory in the cardinal features which any proper experiment should possess—(1) they stimulated thought, (2) they compelled scientific observation and reasoning, (3) they compelled accurate and careful work, (4) they were not too difficult, (5) they taught definite facts, (6) they were intimately connected with the classroom work.

Another experiment which was very useful was one with the Jolly Balance to illustrate proportion. This was performed as a lecture experiment. A full account of this experiment appears in School Mathematics, March, 1904.

As far as can be judged from a single year's trial, physics laboratory experiments performed by the class in connection with Plane Geometry were not especially helpful, but occasional lecture experiments which had a direct mathematical application and which gave quite exact results may be of great assistance in enlivening and explaining the subject. Also, from the single year's trial it seems that experiments in plotting curves and finding areas graphically are well worth doing in connection either with geometry or algebra. Where used; I can see no reason for any radical departure from the way in which algebra is at present introduced.

As to the introduction of the subject of geometry the method of observation and experiment can, and I believe should be extensively used. To put off its introduction until the first or second High School year (ninth or tenth grade) is, however, too late to realize the most reliable results. Fractions can be given concreteness by the actual handling of graduated rulers and this is a device which is already quite widely used. The laying off of lines of definite length is a simple exercise, but it is a most valuable experiment, introducing as it does drawing to scale. Decimal fractions can be very beautifully illustrated and familiarized by the practical use of the meter stick. The metric system is then learned as a convenience and not as an added task.

Nowadays drawing is taught in almost every school. It is unfortunate that so much time is wasted in trying to make artists, in drawing from natural objects which do not possess definite geometric form when natural objects could just as well be selected which do have definite geometric form—cubes, cylinders, spheres, crystals, crystal models, buildings—and, while these objects are being drawn, they can as easily be drawn geometrically, *i. e.,* to scale. The quality of exactness is thus added to the observational practice sought. The educational value is correspondingly increased. This subject of observational geometry for the fifth, sixth, seventh and eighth grades has been very satisfactorily worked out in the book by that name written by William G. Campbell of the Boston Latin School, and published by the American Book Company. The course in drawing could well be combined with arithmetic greatly to the advantage of the latter and thereby giving a valid excuse for the existence of the former. Its value would be enhanced by including a number of the simple

constructions of mechanical drawing as outlined in any book on the subject, for instance, Anthony's "Mechanical Drawing" (D. C. Heath & Co.).

Armed with such a fund of information the introduction of formal demonstrative geometry would be robbed of its terrors. At present we are basing a system of logic on a subject in which the facts even are unfamiliar—a procedure which is surely illogical. Also the time actually required would be less and an opportunity would be given for many simple and valuable exercises in measurement in connection with Plane Geometry, for which there is now no time.

The objection will be raised that the work of the grades is now so crowded that there is no time for such work. In answer, first, observational mathematics takes no more time than mathematics and drawing as at present scheduled, and the former serves the double purpose; second, a judicious pruning of subjects and of time given to non-essential subjects in the grades would be a lasting and much needed improvement. The subject most curtailed should be nature study in its present form. For young pupils observations on animals and plants are too fanciful and indefinite to be scientific. The same effort devoted to observational geometry would accomplish in a satisfactory manner the object sought, which nature study, so-called, does not do. Until the much needed reform below the High School takes place, temporary relief must be sought by the sandwiching of the work desired into present courses, and I believe it possible to do this without demanding additional time. A day now and then from the algebra recitation given to the use of curve plotting is well spent. If skillfully and slowly introduced, by the time simple simultaneous equations are reached many solutions may be graphically obtained with great stimulation of interest. The use of the terms variable, constant, function, etc., need not be avoided, but, on the contrary, should be systematically employed and exactly defined. One defect of our mathematics training is the increasing willingness to allow a pupil to give a definition in his own words with a corresponding sacrifice of exactness and accuracy. The pupil should be led to understand the definition as stated by some authority and be compelled to abide rigidly by that definition. A definition thus learned is something to tie to in

after years and is a most convenient reference point for the checking of error.

In geometry the use of a circular protractor can be quickly and easily learned. The construction of isosceles, equilateral, right triangles, of triangles equal to given triangles, etc., etc., can be assigned one exercise a day without the pupil noticing the extra work and with great benefit to him. The solution of these easy exercises gives him confidence for the harder ones to follow as originals.

In the second book of geometry the use of the scale of chords can be similarly introduced and angles measured and constructed. In the third book triangles similar to given triangles, etc. etc., almost all the constructions—will thus be solved as originals with a great corresponding gain of time. A practical exercise which should under no circumstances be omitted is the determination of the height of the building or of a telephone or telegraph pole by setting up a vertical stake some sunshiny day and from its height and shadow and the shadow of the pole determining the unknown height. This exercise can be repeated many times with profit.

The use of cross-section paper for determining irregular areas and for checking the rules for areas of regular figures, should be used in connection with the fourth book. In the assigning of problems it is very convenient to make frequent use of the density and specific gravity notion and these definitions should be rigidly taught.

An improvement in the quality of problems in algebra and geometry is greatly to be desired; but to add concreteness and to make them really practical some very few physical notions are necessary. Among these may be mentioned specific gravity, vectors (parallelogram of forces), velocity.

Any advance along the lines mentioned above must necessarily be slow and should be cautiously and conservatively made. The panacea for all our difficulties does not lie in a laboratory method in mathematics nor in any other method, but in a steady systematizing of our mathematics and associated courses so that each shall support the other. There is also necessary a growth of true scientific spirit among the teaching force that the thinking power of the pupils may develop under the stimulus of observation and experiment.

AN ALGEBRAIC BALANCE.

By F. C. Donecker.

R. T. Crane Manual Training High School, Chicago.

The pedagogical dictum, "From the concrete to the abstract," finds universal acceptance in this age of laboratory education. The idea of teaching through hand and eye in manual training is being put into practice more and more, owing to the great success that has been achieved by the pioneer institutions in this line. Why should not the same principles of co-ordinate activity govern in the teaching of algebra? Can we not clear up some of the most troublesome points by making visual, concrete representations of negative numbers, and of equations?

The apparatus to be described in this article was originally designed to show the nature of transposition in equations. A little experimenting led to the belief that an additional and greater field of usefulness lies in a somewhat different direction. A series of tests with pupils who had studied algebra a half year in the eighth grade, indicated that for a large majority of them negative numbers had no meaning. It dawned on me that the really important thing about the new balance is the fact that by its use these elusive things can be made as real and as tangible as ordinary numbers, and as easily measured as two pounds of sugar or a ton of coal.

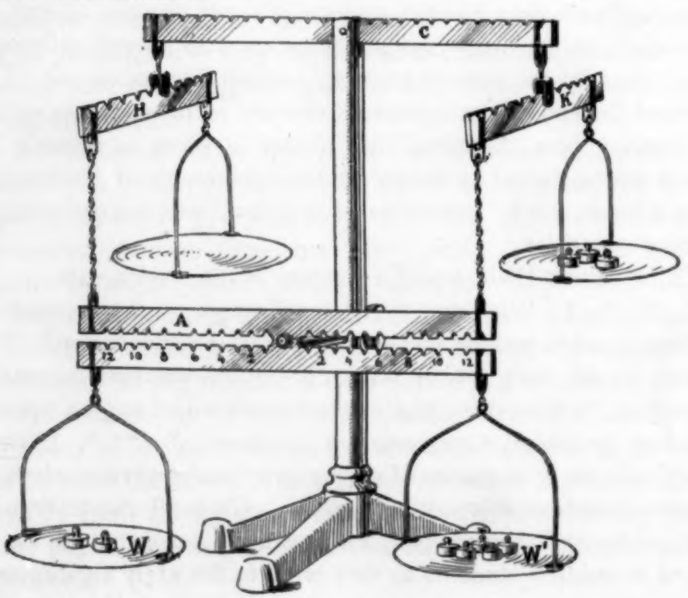
A study of the history of mathematics with special reference to this phase of the subject tends to confirm this conviction. Up to almost the end of the eighteenth century *mathematicians* called negative numbers "fictitious" or "absurd." Even so recently as 1799 a mathematical professor in the University of Cambridge wrote a book called "Principles of Algebra," and argued against negative quantities.

Cajori, in his History of Elementary Mathematics, says:

" * * * Why was the generalization of the concept of number, so as to include the negative, such a difficult step? The answer would seem to be this: Negative numbers appeared 'absurd' or 'fictitious' so long as mathematics had not hit upon a *visual or graphical representation of them.* * * * History emphasizes the importance of giving graphical representations of negative numbers in teaching algebra. Omit all illustration by lines, or by the thermometer, and negative numbers will be as absurd to modern students as they were to the early algebraists."

The invention of this new piece of apparatus adds another means for making visual and concrete these "absurd" things. It has the advantage over those named above by being under the direct control of the manipulator, responding immediately to any desired change, with a rapid and easy method of measuring such change. Consequently it is more convenient and adaptable for experimental work. Its use will be a great help, I believe, in keeping the pupils from getting the notion that algebra consists merely in juggling with symbols, and that signs may be changed at will without more ado.

As may readily be seen in the illustration, the apparatus has a main lever *A,* at whose extremities are suspended weight pans *W* and *W′,* making this part alone an ordinary equal arm balance with not too great sensitiveness. Suspended at right angles from a rigid crosshead *C,* are two supplemental levers, *H* and *K,* for the purpose of changing the direction of the downward pull, caused by a weight pan suspended at one end of each, into an upward pull at the ends of the main lever with which their opposite ends are connected. Consequently the main lever is acted upon at each end by directly opposite forces. Therefore, when in balance, it correctly represents an equation with positive and negative quantities in each member.



To meet a demand for some correlation of algebra and physics the parts of the balance were so modified as to be adjustable in a number of ways. It is possible to change the length of any lever arm used, making it useful in a number of problems in applied mathematics.

Below are indicated some of the visual demonstrations which may be set up by the use of this machine.

(*a*) In pure mathematics:

Addition, subtraction, multiplication and division of positive and negative numbers, including all the laws of signs involved.

All the axioms involving the above operations.

The commutative, associative, and distributive laws.

The transformation of simple equations.

(*b*) In applied mathematics:

The laws of the simple and compound levers.

The law of equilibrium with forces tending to rotate a body.

The law of parallel forces.

Believing that the greatest usefulness of the new balance will be found in providing a connecting link between arithmetic and algebra, proceeding by visual, tangible steps from ordinary numbers to the new and difficult negatives, I will show how some of the fundamental operations only may be illustrated.

Three facts must be emphasized at the outset, although they may seem so clear as to need no attention. The first is that we always measure the weight of an object placed in one pan of a balance by counterpoising with known weights on the *opposite* side; next, placing two or more objects on the same side of the balance is *adding* their weights; and finally, when objects are already on the pans, but balanced, we may *measure the change* produced by further additions, in the ordinary way, simply ignoring the balanced things.

With beginners in algebra there should be practice in ordinary weighing with the upper levers disconnected, then measurement of the combined weight of groups of two or more weights, *i. e.*, measurement of added things, or sums.

Then the upper and main levers may be connected and the effect on the main lever studied when a weight is put upon one lower pan alone, and compared with the effect on the main lever when the weight is put on the corresponding upper pan alone. We have effects which are exactly opposite. To avoid constant

repetition of the words "upward" and "downward" it is desirable to use distinguishing marks and names for the numbers representing the measures of these opposite forces. In previous experiments ordinary numbers were used to stand for the measures of the down pull. They may now be marked + and named positive to distinguish them from the new kind which may be marked — and named negative, in the conventional way. This shows clearly the *opposition in kind* of positive and negative.

It may now be agreed for the sake of brevity to call the lower pans "positive" and the upper pans "negative." Placing equal weights on the positive and negative pans on the same side, the apparatus is in balance as if no weights were on. Here a definition may be developed somewhat as follows: "A negative number is a number which neutralizes, or tends to neutralize, an ordinary arithmetical number when added to it."

We may proceed to add positive and negative numbers by placing corresponding numbers of equal weights on the same side of the balance, and determining their sum by counterpoising with similar weights on the opposite side. If the sum is positive, weights will be required in the lower pan. If negative, in the upper one.

Subtraction may be performed by placing the minuend on one side of the balance, the subtrahend on the other side, and applying the definition: "Subtraction is the process of finding how much must be added to the subtrahend to make it equal the minuend."

To clear up multiplication it is necessary to make plain the fact that + and — have in algebra two distinct uses. As in arithmetic, they indicate operations. Applying them in the experiments with the balance, + of operation means adding, or putting weights, on either lower or upper pans. While — of operation means subtracting or taking off. But it was further agreed that — should be used to designate the *kind* of thing which is found on the upper pans, and that + should be used to designate the *kind* of thing on the lower pans. That is, + and — are also used to show the *kind* or *quality* of numbers.

Suppose a group of three equal weights is placed on one lower pan and that a second similar group is placed in the same pan. As to kind, each group is $+3$. There were two operations of addition, indicated by writing $+2$ as multiplier. We therefore have on one side $+3$ taken $+2$ times. To measure the result we

must *put on* 6 similar weights on the opposite *positive* pan, showing the result to be + 6.

To show that the product of —2 by —3 is +6, the balance is put into equilibrium with a number of weights on it, six or more on a negative pan. A group of two is *removed* from a negative pan, then a second group, and a third group from the same pan. As to kind each group is — 2. The operation of subtraction was performed three times, which is written —3. Therefore the change made is indicated by saying —2 was taken —3 times. Again measuring on the opposite side we find that putting on 6 similar weights on the *positive* pan restores equilibrium, showing the product to be +6.

The writer has used the apparatus in his classes with good results. Pupils of another class were shown the nature of transposition, and of negative number, once only, and that rather hurriedly. After the lapse of several months they volunteered the testimony that it cleared up their ideas and helped them very much.*

ASTRONOMY AS A HIGH SCHOOL SCIENCE.

By Dr. J. A. Miller,
Indiana University, Bloomington.

As to whether atsronomy should be a high school science depends upon so many things concerning which I possess no expert knowledge that I hesitate to discuss it. So much has been learned, or at least written, about the psychology of adolescents since I was a student of psychology that I am utterly at sea whenever I try to draw any hard and fast conclusions touching secondary education or even to apply much of it to two adolescents of my own. Then, too, the purpose of education, particularly of secondary education, has been recently the subject of so widespread and varied consideration and the conclusions reached vary so much among themselves that I am equally without chart or compass in the sea of literature. There seems to be fairly universal agreement upon the proposition, however, that the primary purpose of the high school is not to fit students for college, but for life,

*Mr. Donecker informs the Editor that arrangements are being made for putting this very useful apparatus on the market by the opening of the next school year. Further particulars may be obtained by applying to the writer of this article, 588 East Sixtieth Street.—Mathematical Ed.

whether or not the immediate future life be spent in or out of the schoolroom. If an essential element of this preparation is that the student should learn those things only that may be directly translated into food and clothing, Astronomy should not find a place in the high school curriculum. For there are many other sciences richer in this element of education than astronomy. If this preparation means that it is to train boys that they become scientists then certain other subjects lend themselves more readily to high school methods; there is, nevertheless, much misapprehension as to the time, labor and expense necessary to acquaint a student with the rudiments of astronomy. There is at least one firm that will supply apparatus for a year's course in astronomy, one-half of which is laboratory work, for a cost less than that of equipping the usual chemical or physical laboratory. It is true, too, I think, that as much skill in compelling instruments to give one information and of interpreting and recording results can be obtained by such a course as in the ordinary course in any of the inorganic sciences. The chief advantages that the other sciences have, it seems to me, is that the student is working with processes which to a certain extent he may control, and which therefore he may modify at will, and for that reason they become of commercial value.

If an element of this preparation is to develop power then astronomy may find a place in the high school curriculum. If, farther, one element of this preparation is a campaign for knowledge as against ignorance then astronomy should find a place in the high school curriculum. For, its subject matter, dealing as it does with such momentous masses, separated by such great distances, moving with such great velocities, controlled by stupendous forces according to well-established laws, contains elements not found in any other science with the possible exception of geology. Elements of bigness that appeal with peculiar force to men and women of this adolescent age. It affords him his best opportunity to go to the frontiers of science, where conditions are pure, and unaffected by disturbing influences and the man who leaves school without some knowledge of astronomy has suffered a loss.

In a recent paper G. Stanley Hall says:

Next to English in the high school should come science, which teaches love and knowledge of Nature—the great mother of us all, and from which religion, art and literature as well as science, have sprung. The science and topics chosen should give largeness

of view, rather than precocious accuracy, and we should remember that man was a naturalist long before the laboratory. Youthful curiosity always strangely gravitates to frontier questions, where we all are children and love to play with great ideas, force atoms, astronomic space, and geological time. * * * First, all high school science should always include the elements of astronomy. Naturally the curiosity about the heavens is now almost at its strongest and best, and the result is reverence, for the undevout astronomer is mad. Very little celestial mathematics is needed, that came late, but a meaty body of facts about nebulæ; the number of stars; the distances of those most remote, their motions in systems very different from our own, collisions, comets and dead planets; the sun and moon, which Plato and Aristotle knew no higher gods, the hierology of astronomy which has its saints and its martyrs, its epochs, its culture history and astrology, and what astronomers are now doing. Unfortunately this opinion has not found favor with educators in the United States. The subject has been omitted from the reports of the various committees appointed by the N. E. A. to consider the needs of secondary schools, and school officials generally seem to be hostile to it. In the earlier days no course was considered complete without it. In 1900 only about 3.5 per cent of students enrolled in the high schools were enrolled in astronomy. And in the five years preceding it the per cent had decreased slowly but steadily from 5.2 per cent to 3.5 per cent. It may be of interest to science teachers to know that in this matter astronomy does not stand alone. The per cent of students in every high school science, physical geography excepted, which holds its own, is decreasing. In ten years, 1890 to 1900, physics, upon which the greatest emphasis has been placed by school authorities and educational writers, has decreased from 21.4 to 18.8 per cent; chemistry, from 9.6 to 8 per cent; and for five years, 1895 to 1900, physiology has decreased from 28 to 26.9 per cent, psychology has decreased from 33 to 3.1 per cent, geology has decreased from 5.5 to 4 per cent, astronomy has decreased from 5.2 to 3.5 per cent. In the same period, 1890 to 1900, Latin has increased from 33.6 to 49.9 per cent, French has increased from 9.4 to 10.4 per cent, German has increased from 11.4 to 15.9 per cent, History has increased from 27 to 37 per cent, and in five years, 1895 to 1900, Rhetoric has increased from 31.3 to 37 per cent, and in three years

English literature has increased from 38.9 to 45 per cent. The figures appear better grouped thus, out of 384 per cent of all students in the high school:

79.2 per cent are enrolled in Languages, 78 are enrolled in English, 81 are enrolled in Mathematics, 87 are enrolled in Science, 58 are enrolled in History and Civics.

In Indiana there is practically no work done in astronomy in the secondary schools. A few of the high schools have in the past given courses for some time. Others have recently introduced courses, while others have discontinued them.

But astronomy is now at low ebb in the colleges and particularly in the State universities there has been a distinct revival in the teaching of the science. There has been in the past six years new observatories built and equipped in part at least for teaching purposes. At the University of Pennsylvania, Ohio, Cincinnati University, University of Illinois, Indiana and California, and in addition to these new departments of astronomy put into the universities of Missouri and Nebraska. Beside the recent and now formidable Perry movement in mathematics will give an increased interest to astronomy. So that in the near future I believe that astronomy will come into her rightful estate. The courses in astronomy should be reconstructed somewhat along the lines of natural history and laboratory. It should not consist mainly in finding north and south lines, establishing noon marks, building gnomons, etc. Only enough of this work should be done to insure that the student really understands the subject. The skill of making instruments imparts information to the manipulator and should come from the other sciences. But a part of the study must be made under the sky and be directed by some one who can look the sky squarely in the face, realizing that some of Nature's choicest secrets are hidden there. The purpose should be not to make astronomers, but men.

I am convinced that the study of the more conspicuous constellations should form a much greater part of the study of elementary astronomy than it does at present, and I believe also that this study should form the early part of the course. It must be made under the sky and include a study of their form and location, a generous sprinkle of their mythology, the names and positions of the brightest stars, the location of famous star clusters, double and variable stars and nebulae. An old friend of mine used to

say that "the way to educate a man is to set him to work; the way to get him to the work is to interest him; the way to interest him is to vitalize his task by relating it to some form of reality."

The mythology of these constellations, filled as they are with deeds of chivalry and romance, peopled with powerful heroes and beautiful heroines, appeal with wondrous power to these chivalric youths.

At the request of one of the best teachers of literature in the state a course in astronomy was put into the high school in which she taught because it explained many references in literature. Other myths that have been woven into the lives of peoples or have been made the basis of religious beliefs and practices, or that have found their way into our everyday practices, appeal to these high school students because they have appealed to men of all ages and have in many cases shaped the destiny of individuals and nations. As an illustration, consider the rather repulsive figure representing the signs of the Zodiac in the front of any almanac, the naming of the dog-days, the world-wide admiration of the Pleiades, the naming of the days of the week, etc. And in these things astronomy is far richer than any other science, for the time is not far past since the development of astronomy and civilization was coincident and in learning them he experiences again the travail that gave birth to our civilization.

It is under the sky with these people that one may most wisely decide what may and what may not be in a course in elementary astronomy. It should include the answers to questions asked them and when these questions are all answered the course is complete. In a general way, whether your audience be old or young, the questions are much the same and nearly in the same order as have been asked and are being asked by the professional astronomer. I have found at such times, too, that some of the most significant facts of astronomy may, with advantage, be brought to his notice. Tell a student when he is looking at Sirius that because of slight shiftings of its position Bessel showed mathematically that it had another sun nearly as large as our own going about it, and he gets some idea of the accuracy of the sciences, the immensity of the system, and he will never forget that it is one of the most interesting double stars in the sky. His curiosity should lead him to ask the significance of a double star.

If he is told that a star is a sun he will ask if there are planets going about them. Then show him Algol, the famous variable star in Perseus. One cannot describe its behavior too minutely. He will be interested in knowing that its range of variation is larger and that its behavior is so punctual that one can predict its brightness at any time. If you happen to be with him when it is losing or gaining its light he can see it vary. He will ask you what causes it to vary and the whole subject of variable stars is introduced, and when it is understood that the variation is caused by a dark body going around it, passing regularly between the eye and the star, he will realize that here is at least another sun with a planet going around it and when he is told of its size and period, he will feel that he has beheld a wonderful system. One leads easily now to the subject of double stars and such other subjects as he desires to discuss. Having learned the constellations he will get benefit from platting the moon and brighter planets as they move in the sky. He may also make such observations as are necessary to lead to an understanding of the apparent motions of the heavens. These may be made with instruments of his own manufacture. He may at a cost of 50 cents make him a telescope and a planisphere. If he has a camera let him point it to the pole for an hour or more some moonless night. He will get a picture of the rotating earth. He is now ready to study the sun, and this should be done in much detail, for we know more, very much more, about this star than any other. He should learn much about the new astronomy, the laws of the spectrun, the spectroscope and spectrun analysis. It is possible to illustrate some spectroscopic facts at little expense. He should study the moon, for it is the only dead body that we know, and he should be told that this is the state to which all bodies are tending. He should study the planets, not as so many individuals, but rather as comparative geography. He will be interested in knowing that all have their seasons, their days and nights, their satellites, their mountains and valleys, their clouds, their snows and their rains. Little time should be spent with comets. They are relatively unimportant. Likewise I doubt the wisdom of trying his patience with circles and systems of coordinates. It is much better that he try to understand the laws of the matchless Newton, the laws that with one stroke made chaos into system—laws that have influenced the thinking of five centuries. And last, perhaps, some astrology. One of our duties as teachers is to kill

off superstition wherever it is found, and as the tubercle will not live in the sunlight, so superstition dies in the light of science. So also if the tubercle might die with this generation tuberculosis would disappear; likewise we should be free from superstition if we could eradicate it from this generation. Regarding nothing in all nature is there more superstition than the moon and the stars; an insidious superstition, that effects more or less seriously the efficiency of many men and women. It is perhaps fair to say that such a course as here outlined differs widely from that of any offered in text books now published. The sequence of subjects is in the main the same as they were studied by men, and as they would be developed if they followed the order suggested by the questions of boys and girls.

THE EQUIPMENT OF A PHYSIOGRAPHICAL LABORATORY.

By Jane Perry Cook.

South Chicago High School, Chicago.

About the year 1896, a well known district superintendent of schools in Chicago advocated the substitution of physiography for biology as a study for the ninth grade. He believed that, as physiography was not a laboratory science much expense would be spared the city because it would be no longer necessary to equip and maintain laboratories for the large first year classes. The change was made and physiography has ever since been taught in the first year of the high school course.

Within the past five or six years, however, the teaching of the subject has undergone a radical change. It is no longer taught from text books alone, but every possible means is used to acquaint the pupils with materials and phenomena at first hand.

While physiography is not a laboratory science in the generally accepted sense of that term, in no science is it more necessary to use illustrative material. The use of such material has been found inconvenient in the recitation rooms furnished with ordinary desks, It is necessary to have a place where the pupil may spread out his maps and charts, and can work with globes or consult reference books without this limitation imposed upon a crowded class room with desks in set rows.

To meet this need all of the high schools recently built in Chicago have been equipped with physiographical laboratories and, in a few of the older buildings, certain unused rooms have been furnished with the necessary tables and storage plans to make useful and practical workrooms. Although these laboratories are more convenient than the old-time recitation rooms, the ideal workroom has not yet appeared.

This paper is an attempt to describe some of the laboratories which have recently been put into use, to picture their equipment and to present such arrangements and devices for storing apparatus as have been found convenient in different schools.

As laboratory work in physiography differs widely from such work in all other sciences the laboratory must be planned with this difference in mind. Five things are essential: Plenty of light, plenty of room for the pupils to move about; tables where materials may be spread for inspection; running water which may be so manipulated as to illustrate river work; and convenient and accessible receptacles in which to store the often bulky materials required.

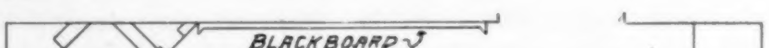


FIG. 1

Plan of Physiography Laboratory in the Wendell Phillips High School Chicago

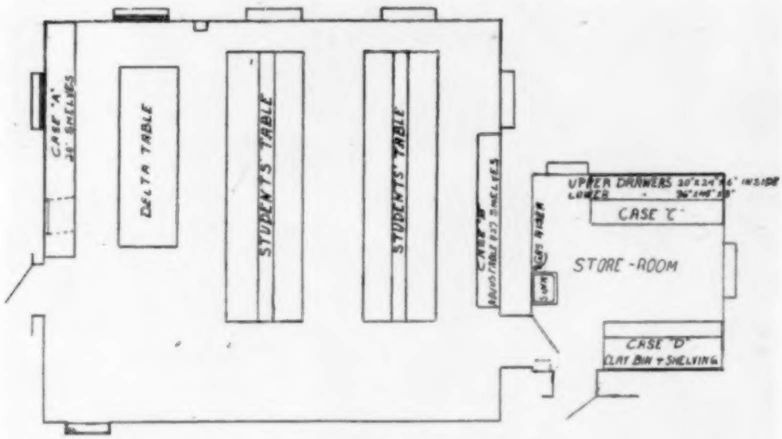


FIG. 2

Plan of Physiography Laboratory and Store Room in the South Chicago High School, Chicago

Figures 1 and 2 show the plans of two laboratories recently installed in the Chicago High Schools. The first is in the beautiful new Wendell Phillips High School, the second, in the South Chicago High School. The latter is an old building and the only available space was divided into two rooms which could not be thrown together because the division wall could not be removed without weakening the building.

The general plan of arrangement is alike in all schools; two long work tables for students, separated by a wide aisle; a delta table designed to show erosion, deposition, etc.; and such cupboards, bins and drawers as the wall space admits. The students' table is so arranged as to fit all the uses to which it must be put for here the students must write, study maps, and do whatever modelling with sand or clay may be required. To this purpose the table shown in Figure 3 is well adapted. The upper part, which serves the purpose of an ordinary desk, consists of a movable drawing board supported at the farther end by an inchwide projection running lengthwise along the top of the table and kept from slipping by a rim an inch in height. This board can be easily slipped into place and as easily removed when it is necessary to use the lower part of the table which is essentially a shallow, lead-lined, sink with the floor pitching away from the student.

FIG. 3

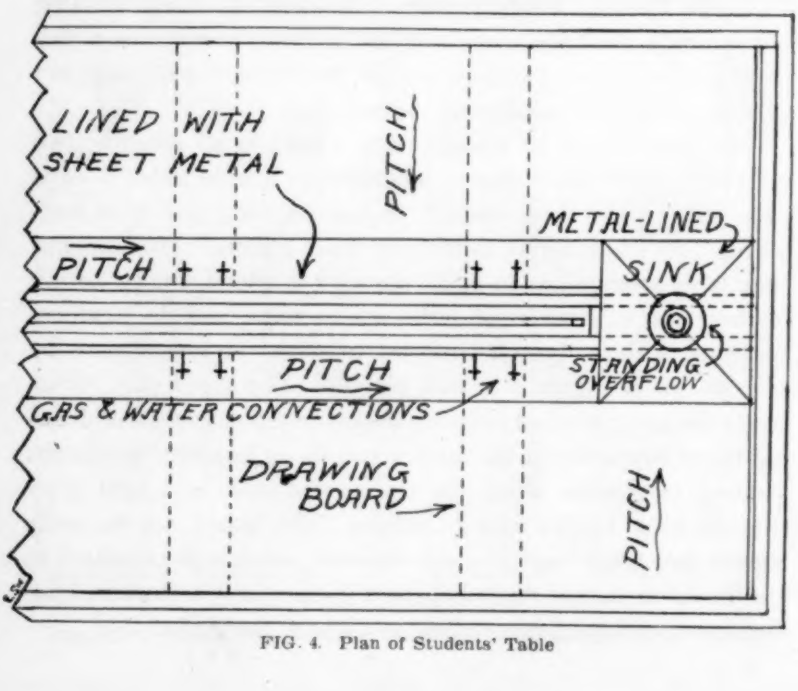


FIG. 4. Plan of Students' Table

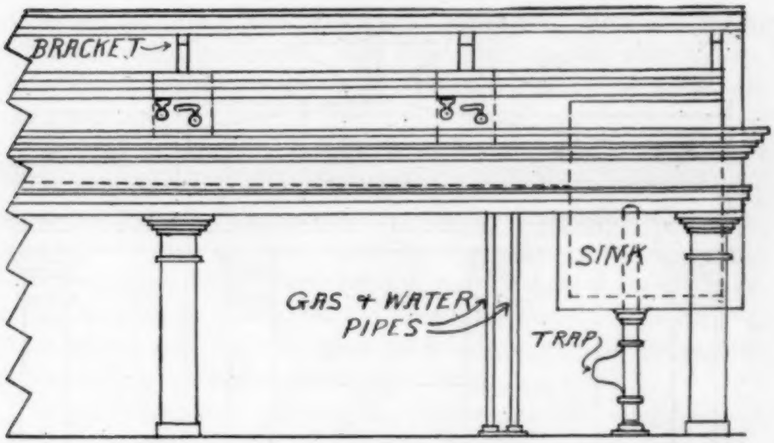


FIG. 5
Elevation of Students' Table

At one end of each of the students' tables and also in the side of the delta table, there is a space for storing the drawing boards when the table is in use for other purposes. This space is provided with cleats between which the boards are held to prevent warping.

When the drawing boards are removed, there is exposed a long table dipping away from the student at a low angle and draining into a shallow gutter five inches wide and three inches deep, which runs the length of the table and empties into a box-like sink (see Figures 4, 5 and 6) with a standpipe eight inches high, where the sand may settle and be removed to avoid clogging the drain. The purpose of this gutter is twofold; it furnishes a means by which water may be drained from each student's modelling table, and gives a long uninterrupted flow of water down a gentle slope, where some of the conditions governing erosion and deposition may be studied. The floor of this shallow sink may also be used as a modelling table and for such simple experiments as may be desired. Each student's place is supplied with stopcocks, one for water, to which is attached a length of rubber tubing ending in a sprinkler with fine perforations, the other for gas. (See Figure 3.)

The delta table is used largely for demonstration work by the instructor. It is 11 feet long, 4 feet wide and 3½ feet high. The top of the table (see Figure 7) is divided into three parts. The first two divisions slope in the direction indicated by the arrows

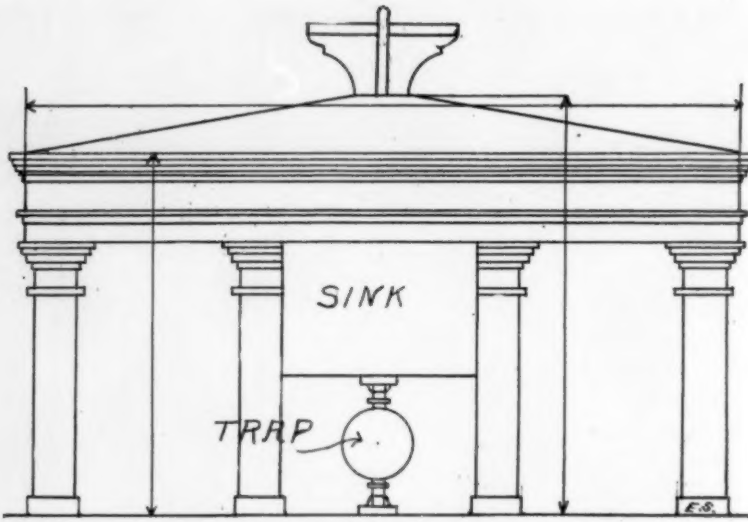


FIG. 6
End Elevation of Students' Table

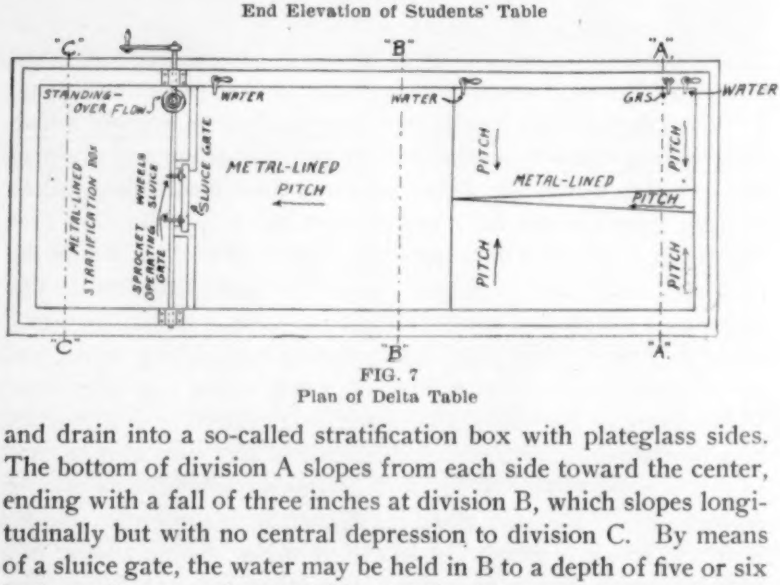


FIG. 7
Plan of Delta Table

and drain into a so-called stratification box with plateglass sides. The bottom of division A slopes from each side toward the center, ending with a fall of three inches at division B, which slopes longitudinally but with no central depression to division C. By means of a sluice gate, the water may be held in B to a depth of five or six inches. By use of a sprinkler to simulate a rainstorm playing upon a continent or island planned in A, many of the phenomena of river action may be illustrated effectually in miniature. The wasting of continents, the differential erosion of land masses, the carrying of waste to the sea and its deposition in still water may be worked out in an interesting way. Figure 10 shows such a

delta laid down in a quiet water in B, which was afterward drawn off to show the delta form. Just above the delta the gully is seen from which running water eroded the material out of which the delta was made.

Part C of the delta table is a foot lower than part B from which it is separated by a sluice gate. Three sides of this division are of plateglass. In this tank the process of river sorting may be shown by varying the force of the running water at A. The most of the work possible at the delta table may be done at the students' tables, but the advantage of the larger table is that it affords a place where work may be done on a large scale and carried on for several days without interruption from class work.

A good means of securing a rainstorm on the delta table is yet an unsolved problem. Various devices for obtaining a gentle downpour on part A have been tried. One in use in the Hyde

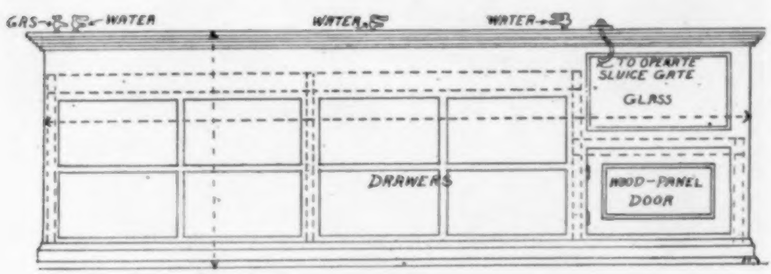


FIG. 8
Rear Elevation of Delta Table

Park High School seems to be the most practical. An upright pipe at the head of the table carries the water to a height of four feet above A. A pipe at right angles to this upright ends just above the center of A. To this arm is attached rubber tubing, terminating in a large sprinkler resembling the end of an ordinary watering pot, but with much smaller perforations.

A in Figure 2 is a cupboard for the display of rocks and minerals. The shelves are mounted upon movable iron brackets so they may be inclined at any angle to show the specimens. On the wall space above each shelf, a card may be placed naming its contents.

When a laboratory serves the double purpose of workroom and classroom, the plans here shown lack two essentials: a platform and a table to hold whatever material for demonstration the

instructor may wish to use. The platform should be high enough to bring all experiments done at the desk into plain view of the entire class. The demonstration table may or may not be furnished with a sink, water, and gas, but should be large enough to hold conveniently all the material required for a lesson. In all cases the aisles should be wide and the students' tables should occupy the center of the room as in Figure 2.

A very important part of the laboratory is a storeroom for apparatus. This room should be well lighted and the material so placed as to be readily accessible. There should be an abundance of enclosed shelves and drawers. A convenient storeroom is shown in Figure 2. It communicates directly with the laboratory and is well lighted by two windows. C is a case of 28 drawers,

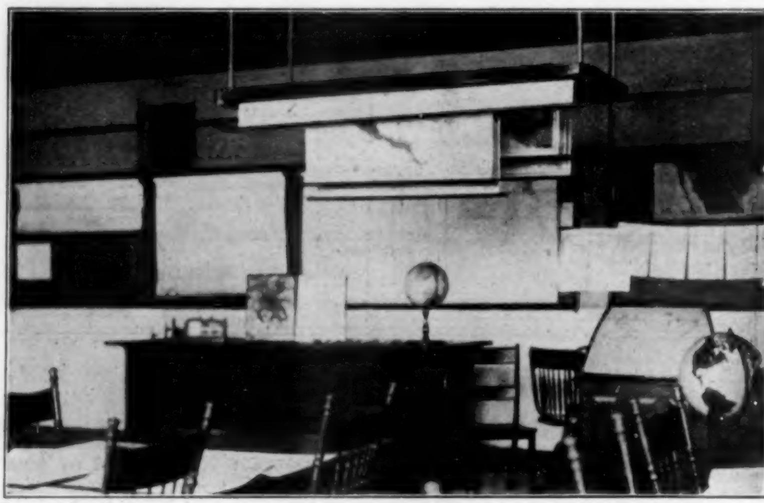


FIG. 9

each of which is large enough to hold three sets of 28 each of mounted topographic sheets. The drawers not so used form convenient receptacles for all sorts of material. On the outside of each drawer a printed card slipped into an iron frame shows its contents. The lower part of each case projects a foot beyond the upper portion and is divided into two drawers 36 by 46 inches and 8 inches deep, convenient for holding Coast Survey and Pilot Charts.

On the opposite side of this room is built a case, the upper part of which is made to hold a set of globes. Half of the lower

part holds a set of Harvard Models, while the other half is occupied by a clay bin, built like an old-fashioned flour bin, so balanced as to tip back and forth easily, even when holding two barrels of molding sand.

A sink is placed against the third wall of the storeroom. It is supplied with gas and water so that gases may be prepared when classes are studying the atmosphere.

With so much of the wall space of a laboratory devoted to
radius *r*.
cases and blackboards, it is often difficult to find sufficient room to hang maps so they are in plain view of the pupils. A very convenient arrangement is that in use in the Joliet High School. This school has a large equipment of topographic maps of various

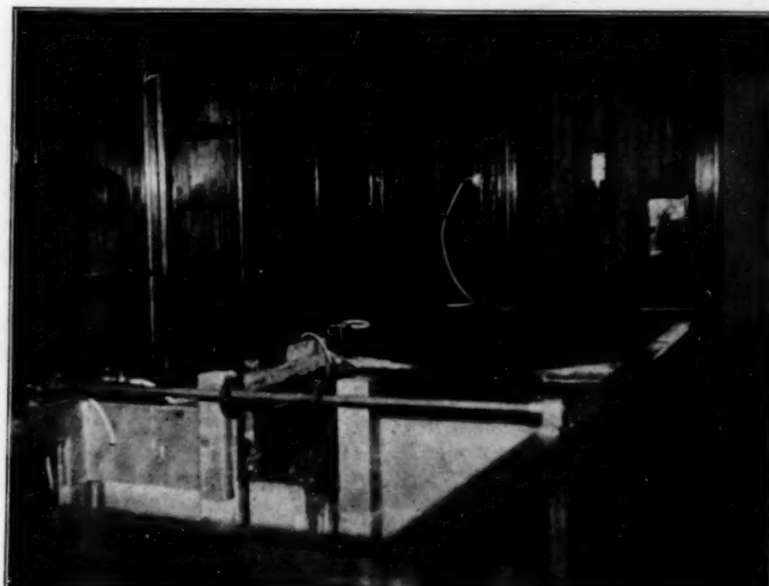


FIG. 10

regions made by joining topographic sheets. These maps are mounted in the usual manner upon rollers. When not in use in the class room they are kept upon a rack in the store room, each map plainly marked on the outside. When needed in the recitation room, the unrolled map is supported by a frame consisting of a cross bar resting upon an upright seven feet in

height, the whole resting on a cross-shaped base on casters. The map can thus be moved to any part of the room. For very long maps, such as the map of the Mississippi, a convenient arrangement has been devised. A wooden box on casters holding the map on a spring roller is attached to a jointed upright, the upper half of which can be folded back. When needed for use, the folded upright is raised and bolted to the lower part. The map is then raised by a cord passing over a pulley at the end of the upright. Still a third arrangement for securing map space is shown in Figure 9. Four metal rods, descending from the wall, enclose a box-like case made to hold several maps, any one of which may be unrolled as needed.

If the blackboard space be limited, it is possible to add to it by the device shown in A, Figure 1. This board is in three sections enclosed in a heavy wooden frame. When one section is covered with work, another may be pulled down.

The question of expense is an interesting one to those about to fit up a physiographical laboratory, but no very definite information can be given on that point because the cost of work and material differs so much in different places. The published proceedings of the Chicago Board of Education show that the laboratories placed in the old buildings have cost from $1,000 to $1,350, but this expense might be lessened by using galvanized iron or zinc in place of the sheet lead lining the students' and delta tables. In schools where running water is unavailable, and sinks therefore unnecessary, long, wide tables are convenient. These tables may be made proof against the action of acids and marring from the use of rock specimens by having a coat of paraffine ironed into the wood. Such tables have been found satisfactory in Joliet.

Convenient laboratories, well equipped, certainly are a great aid to the teacher of physiography in crowded cities, where field work is impossible on account of the great distances to be covered and the consequent expense to the pupils, but that teacher should be happy in whose neighborhood field work is possible, whose delta table is some gully nearby and whose sand pile is the lake shore. For this no laboratory can offer a substitute.

THE STATUS OF THE PHYSICAL SCIENCES IN THE HIGH SCHOOL.*

By G. C. Bush.

Marion, Indiana.

This is not a new theme. However, I believe it to be a live one. Much that has been said and written within the last few years concerning physics and chemistry, in fact sciences teaching in general tends to leave a bad taste in the mouths of those engaged in presenting these subjects. Perhaps they are responsible for the criticism falling on this phase of high school work. Perhaps the subjects themselves are not what was claimed for them; or again perhaps we are not on the right tack and have yet to work out a new method for each subject, following a new and commonly accepted point of view and utilizing the great possibilities which educators say these subjects possess. At any rate there are evidences that the sciences, and science teachers, are being adversely criticised. Often the charges are not specific, but abound in expressions which indicate that in some way the sciences are not meeting the claims made for them.

Much of the discussion of this subject has been precipitated by the 1901 report of the U. S. Commissioner of Education, which brings out the fact that since 1889 physics and chemistry have steadily lost in the percentage of pupils engaged in their study, whereas Latin and Algebra have gained. The statistics show that the per cent of total number of secondary students in public high schools taking Latin has grown from 38.88 in 1892 to 50.07 per cent in 1902; German from 10.43 to 16.25; Algebra from 48.93 to 56.15; Physics from 22.82 to 17.48; Chemistry from 10.17 to 7.37.

Commenting on this report the editor of the *Popular Science Monthly* for April, 1904, says after some defensive arguments: "Still there are reasons to believe that physics and chemistry as taught in the high school and college are not attractive to students. Indeed, we have grounds for fear that the high school course as a whole is not so useful as it should be, especially for boys."

Dr. G. Stanley Hall, in his recent work on Adolescence and in an address before the Eastern Association of Physics Teachers, said: "Despite its marvelous growth as a science, physics is now well along in the stages of educational decadence."

* Read before the Indiana State Science Association, at Indianapolis, April, 1905.

At the last meeting of the Central Association of Science and Mathematics Teachers, held in Chicago, a paper was read on "The Decrease in the Number of Pupils of Chemistry in the High School—Its Cause and Remedy."

Supt. D. L. Bardwell of New York, in a paper before the Physics Club, said: "Within the recent past science has apparently been losing ground. Certain tendencies are working against science teaching since the introduction of laboratory work, etc., etc." This much, I think is sufficient to show us that we are under criticism.

The history of secondary physics and chemistry teaching is brief. Neither can lay claim to more than twenty years of trial in the United States, especially along approved scientific lines. Each has undergone a rapid evolution. Chemistry has grown from a study of a few gases followed by qualitative analysis of an unsystematic kind to a well organized treatment of general chemistry, including much laboratory work, some of a quantitative nature. Physics as a high school science is older than chemistry. It has grown from a strictly text-book subject of more or less indefinite purpose and called natural philosophy to a carefully organized and systematic study by text and experiment of physical laws and phenomena. Along about 1893-94 the sciences, and especially physics, received a great impetus in this country. This was due largely to the report of the committee of ten which so strongly recommended the study of physics in the high school. Many rash and absurd claims were made for it. It rather took things by storm. An immediate departure from classical courses resulted, and science subjects were substituted. At this time, 1893-94, the pinnacle was reached—25.29 per cent of all the pupils being then enrolled in physics. Text-book writers got busy and soon a number of books planned along various lines and with various purposes in view were placed in the hands of teachers, often poorly prepared to present them. High schools were demanding teachers of science and higher institutions were attempting to supply the demand, though just what was wanted was known neither by the school nor the college. Should it be surprising if science teaching suffered by comparison with the teaching of the classics, which has been in practice for centuries. It seems to me that of all the high school subjects the sciences require special preparation for their successful presentation, not the home-made kind, away

from all laboratory facilities. The teacher must have the scientific spirit if he will succeed and this is gotten by thorough and properly directed work in the laboratories of science. Little can be expected of a high school course in physics or chemistry if presented by a teacher who has had only a term's work on the subject. Add to this a poor equipment and, I say, Do something else—have spelling—don't be a party to the willful murder of the subject. Think of school authorities employing a teacher for German who has had a year's preparation in this language. They do not hesitate to give two or three sciences to the teacher who has prepared to teach not science, but history, mathematics or languages. I visited a high school this year in which an overworked teacher, prepared to teach mathematics, was conducting the work in chemistry. The work for the day consisted of a study of lime and calcium sulphate, according to some directions written on the board. The pupil was instructed to treat $Ca\ SO_4$ with HCl filter and set aside to crystallize. The formula for lime was written Ca OH. To my mind it would have been infinitely better if those pupils had had two recitations a day in mathematics, for the teacher did well in his line. Let's sacrifice breadth, if in attempting to give it we sacrifice both depth and breadth.

Concerning the report of the Commissioner of Education, it may be said that the whole truth is not revealed. During the time covered by the report, viz., the twelve years from '89-02, high school courses have undergone many changes. A prescribed course which every one had to take and which included physics and often chemistry has been replaced by one embracing a much greater number of subjects, many of them elective, especially in the last two years of the course where physics and chemistry are nearly always given. Chemistry is usually elective and physics often so. In these last two years, pupils elect half of their work from a list of subjects and are often influenced by the amount of work and time required by the subjects. Pupils like to do all their work in school. They know that laboratory work requires two periods in school and time to write up notes. The keeping of notes pupils usually dislike. Most of us did, even in college, where we recognized their value. Pupils will prepare a recitation lesson in one period and recite it in another and thereby finish the work in that subject for the day. Not so with a laboratory science subject.

It seems to me that the statistics are wholly inadequate for comparisons of growth, etc., due largely to the rapid evolution of the high school course in general and to the lack of uniformity in the content of the course. The statistics in no way show conditions like these. In a school of 100 pupils that I was formally connected with, chemistry was required in the junior year, and the class enrolled eighteen pupils. In the school of three hundred and twenty-five pupils I am in now, chemistry is elective in the senior year in which are offered as elective the following: Astronomy, German, Latin, History, Physiology, Botany, Physics, Chemistry, Mechanical Drawing, Free-hand Drawing, Higher Arithmetic, Music and Solid Geometry. English is required. The senior class averages about thirty-five. In all the larger high schools the number of electives increases yearly, thereby reducing the number in any one subject. Statistics that would show us the per cent of those that can take a subject that do take it would afford us a better basis for comparisons.

Concerning the criticisms of Supt. Bardwell of New York I wish to say a few words. He thinks too much time is consumed in the Physics Laboratory; that owing to indefiniteness of purpose and need of constant direction, one-half the time is not used to the best advantage by the pupils. They are not putting forth effort, and when not putting forth effort, they are not acquiring power. We will all concede that power comes from effort, but do we as teachers of physics get less effort than teachers of any other subject? Do we not get more? Supt. Bardwell says that for the entire preparation of a lesson in language or mathematics the pupil is required to think continuously and consecutively and this leads to power. How many pupils put in a period at close consecutive thinking in preparation of a lesson. Visit an assembly room and note the hasty flights from one lesson to another. How much of the work in mathematics and language is done on the co-operative plan? Even with the closest and most persistent vigilance, the teacher is powerless to prevent such division of labor.

Dr. Hall, in his *"Adolescence,"* explains the cause of what he calls the educational decadence of physics this way: "Neglect and the violence done to the nature and needs of the youthful soul." He thinks more of the hierology of physics should be given; that the work is too quantitative, that boys should have more dynamics since they are chiefly interested in the go of things;

that very much thoroughness and perfection violates the laws of youthful nature and of growth, and that the high school boy is a utilitarian and should be given the applications of the science before the treatment of laws, forms and abstractions. The age of pure science he thinks has not yet come. The boy he says is in the popular science age and wants and needs great wholes, facts in profusion, but few formulae. The subject matter of his curriculum is too condensed; too highly peptonized for healthful assimilation; and we are too prone to forget that we can only accelerate nature's way, but never short circuit it without violence.

There is no question but that much that Dr. Hall says would result in good to the work if employed by the teacher, but there are many of us who will disagree with his idea of the general plan of the work. Entertainment is not the function of the work, nor is it the creation of an incentive to do some real work in the subject some day. Any subject should stand or fall accordingly as it does or does not give useful training, does or does not prepare for life. Dr. Hall says that for disciplinary value physics is unexcelled. The subject itself then is not on trial. The trouble so-called then is with the method. He would have more qualitative work, more of the historical and spectacular side of physics in order to arouse interest, thereby laying the work open to the charge that no training is given. Should quantitative work, the disciplinary value of which is great, be sacrificed simply because it is supposed to be less interesting than quantitative work? Is interest the object of mathematics or Latin? Interest is necessary in any subject, but it is only a means to an end. Physics is a difficult subject, not one likely to be elected by the lazy. I see no reason why it should be popularized by taking away the very things that give it great disciplinary value simply to increase the per cent of pupils taking it. Pupils will always differ in tastes and many would not take physics, no matter how presented. Those who do want it should be given the opportunity of getting it in a way that will both enhance complete living and be preparation for further work in some higher institution. I do not believe it is the function of physics and chemistry to arouse interest in the dull or lazy, though they frequently do accomplish this result and always will on account of the flexibility of the laboratory method which enables the teacher to diagonse and prescribe for the individual rather than the class. The goal is not the large per cent of pupils, but the satisfaction in

enabling some to discover their bent, in developing power through the agency of subject matter which has other pedagogical attributes than the educational means afforded. The informational side of these subjects is of no little importance in this age of invention.

Whatever improvements are made in the presentation of these sciences will be due almost exclusively to the efforts of the science teachers themselves. This association has unquestionably done the work much good. It is simply a matter of both individual and united effort. Let us hope for their continuation.

EXPERIMENTAL LECTURES.

By Harry D. Abells,
Morgan Park (Ill.) Academy.

At the meeting of Central Association of Science and Mathematical Teachers last November a teacher, in discussing the high school fraternity problem with me expressed a wish that our high school buildings might become centers for student activities. Although the speaker evidently had in mind the social side of school life, his remarks called to mind a plan that we have been following for over a year, which involves the occasional use of the buildings outside of the regular hours. It is simply the giving of experimental lectures of a more or less popular nature to certain groups of our students.

They are valuable in the first place because there are many interesting topics in connection with our subjects which we have not time to develop during our class hours. In the second place, we are usually blessed with a few students who have a real scientific bent, and these lectures help to keep alive and to stimulate their tendencies in this direction. Again it is possible by this means to come in contact with our students in a pleasant manner. An evening hour spent in this fashion will often lubricate the mental workings of some members of the class who do not take naturally to mathematics and close thinking, and cause them to attack the text a little more vigorously. Also they bring us into touch with members of the school who are not in our classes, but who may be led by these sugar-coated doses to take the course in the regular allopathic manner. Another important service here is giving some students, who may leave school before reaching the advanced subjects, an idea of what science is. Furthermore, they

furnish a legitimate and enviable means of magnifying our subjects in the eyes of the students, other members of the factulty, the executive officers, and possibly our own.

From the various classes of people mentioned as attending the lectures, you may conclude that the idea is to post a public notice inviting all who wish to attend to do so. On the contrary, there is no surer way of making the plan a failure than by trying to get out a crowd. We assume that it is a privilege to attend and invite in those groups and individuals whom we think will enjoy the lecture and receive profit from it. In only two instances have we had the experiments in a larger hall than the laboratory lecture room, which seats about fifty people. Since each one must work out the matter for himself it seems presumption to add subjects or lists of experiments. Consequently what follows is merely suggestive. One lecture was on the topic, "Water." The subject was discussed from a chemical standpoint.

A partial list of the experiments follows:

1. Electrolysis of water.

2. Preparation of hydrogen. *a.* Electrolysis. *b.* Action of potassium upon water. *c.* Action of hydro-chloric acid upon zinc.

3. Properties. *a.* Burns, but does not support combustion. *b.* Singing flame. *c.* Density, power upward, soap bubbles that float on the air, etc. *d.* Occlusion (Pyrography). *e.* Diffusion.

4. Preparation of oxygen.

5. Properties of oxygen. Supports the combustion of phosphorus and iron picture wire.

6. Synthesis of water. Explosive violence of the union of the gases illustrated by means of oxy-hydrogen pistol, and also by the explosion of soap bubbles containing oxygen and hydrogen.

7. General experiments on topics such as reversed combustion and the preparation of water-gas.

As you have observed, there is nothing new in the set of experiments, and perhaps if strict continuity of them were demanded some would have to be omitted. I depended upon the fireworks element to hold the attention of those present, and upon what I could say to keep the lecture fairly scientific and instructive. A considerable time, however, was spent in making the ap-

paratus of such a kind as to bring out the points well and often in a startling manner, even to those in the back part of the room. For example, in the one illustrating diffusion of gases the regulation porous cup was used, but instead of having the added pressure act on the surface of water and force it out of a tube, the porous cup led to a V-shaped tube, open at one end, but containing enough mercury to fill the curve and confine the gases. In this case when the vessel of hydrogen is brought over the porous cup the mercury rises in the open arm of the tube. In order to demonstrate this an electrical connection is made through a bell by means of sealing a platinum wire into the bottom of the curved part of the U-shaped tube as one connection; and bringing the other wire from the cell to within a few millimeters of the surface of the mercury in the open arm; consequently when the mercury rises the circuit is completed and the bell rings. This may be repeated several times by first removing the jar, when after a few seconds the bell stops ringing; and then upon replacing the jar it rings again.

Another lecture was on the subject "Soda Water." Home-made soda water, by means of a siphon and "sparklets," was prepared. The general preparations and properties of carbon dioxide were discussed. And experiments, such as the freezing of berries and making a mercury hammer, were performed to illustrate the properties of solid carbondioxide.

A third was upon the rather vague topic, "Some Scientific Facts and Paradoxes." A partial, general list of the experiments follows: Experiments showing, 1, atmospheric pressure; 2, the phenomenon of boiling; 3, hydrostatic paradox; 4, cartesian diver; 5, the action of sympathetic ink; 6, passive iron; 7, some explosives and colored lights.

Another was upon "Wireless Telegraphy and the X-Ray" and another upon "Photography."

The most important feature in presenting such lectures is to have apparatus so carefully devised and arranged as to bring out the points under discussion in a striking and obvious manner. Much interesting and profitable thought may be given to this developing of new experiments to demonstrate old principles. It really serves much the same purpose as other research work. In showing the properties of carbondioxide I used a simple piece of

apparatus which Dr. Alexander Smith devised for one of his lectures. It consists of a V-shaped trough with lighted candles stuck along the bottom and set up with one end raised about a foot. Carbon dioxide is then baled out of the large jar in which the gas is stored by means of a pail, or siphoned into a pail like water, and poured into the higher end of the trough. It is heavy and runs down hill like water, extinguishing the candles. Again in illustrating air pressure, a cylinder a few inches in diameter, closed at one end and containing a movable piston, was used. A platform was attached to the piston and a boy placed upon the platform. The air was exhausted from the chamber through a valve in the fixed end. Another experiment that proves that the atmosphere exerts a tremendous weight, is to boil water in a large can until the air is driven out, then stopper the can and allow the water vapor to condense. The startling result may be hastened by pouring cold water over the can. Neither of these experiments is new, but each can be seen and understood by all in the room. In the shop talk on photography it is possible to take a flash-light of the group, develop the plate, and print pictures from it, all in the course of the demonstration. In working with sympathetic ink, for another example, it is well to have the experiment done in a large way. We had some pictures and signs made in a lightning artist fashion. Nothing was visible until we ironed the paper with a heated flat iron.

The taking of classes on trips to visit the technical industries in order to get a first-hand insight into the various processes is regarded as a valuable privilege. It seems to the author that this giving of informal lectures offers a similar opportunity not as generally grasped as it might be.

THE HIGH SCHOOL SHOP.*

By Professor J. P. Naylor,
De Pauw University.

When Prof. Rowland was called to take charge of the work in physics at Johns Hopkins University and began to furnish the equipment for the laboratory, much comment was excited by the amount expended for the tools for the shop. Instead of filling his shelves with handsome apparatus, he bought fine tools and

*Read before the Indiana Science Teachers' Association, April 29, 1905.

appliances with which to make apparatus. The magnificent results of the succeeding years abundantly justified his judgment in regard to the purchase.

In my judgment, a shop furnished with proper tools is as essential to the complete equipment of a laboratory for elementary work as for the research laboratory and the expenditures for it are as fully justified. Even with the most careful handling apparatus will get out of adjustment and under the unskilled and sometimes careless use of beginning pupils it is continually breaking down and getting out of order, and place and tools must be provided for its repair. Even if there was no other reason for supplying a shop this item alone would justify the furnishing of one. But any teacher of physics who deserves his place and salary will continually have new devices and ideas occurring to him that can only be worked out if he has a shop in which to develop them. Many times he can supply a much needed appliance for the laboratory at a slight cost for material that will better suit his needs and be much less expensive than that furnished by the dealers. Besides this, the education of hand and eye and the development of manipulative skill that the shop gives is absolutely invaluable to the live teacher of physics.

There is no thought that the shop here suggested should be used for manual training purposes with the pupils, though, sometimes, pupils may be found that may be used in the shop with much profit to themselves and the teacher. This shop, however, is needed and designed primarily for the work of the instructor, and, to serve its best purpose, tools and shop must be kept in order so that the odd minutes and hours can be utilized without loss of time. This can not be done if the pupils are allowed to use the shop as they please. Nothing is so exasperating to a careful workman as to find his tools dulled and out of order and misplaced when he wants to use them, and he will certainly find them so if the pupils are allowed to have free access to them. The shop, or at least the tools, must be kept under lock and key, to be used only under the immediate direction of the teacher. The writer has had experience and knows whereof he affirms.

It has been suggested that the work of the association should be of a somewhat practical character. The following list of tools, with prices, is therefore given with the hope that it may be helpful to some who are contemplating a purchase, or, what is of

more importance, that it may encourage some to fit up a shop who have had no thought of doing so because of the fear that the cost would be excessive or prohibitive.

The prices given below are only suggestive, for dealers will differ somewhat as to prices. But those appended are mostly taken from a recent bill made by an Indianapolis dealer and are not far from the average.

It will be observed that nothing is said in regard to a room for the shop. Usually this will have to be determined by the space available in the High School building. The only necessary requirements are that there be good light from one or two large windows, for shop work is close work and often somewhat trying on the eyes, and that there should be no dampness to affect materials, lumber, steel, etc., used in apparatus construction. For these reasons a basement room is not usually a desirable one for the shop, and an upper room should be secured if possible.

The list of tools is divided into two classes. In the first class are included those that are most essential, or absolutely essential, we might say; in the second class are placed those that are desirable, but that can be omitted in a first purchase, but that should be added to the shop equipment later.

The list of the first class will include the following:

First, a woodworking or carpenter's bench. An excellent 6½-foot bench, with built-up maple top, vise and tailscrew, can be obtained of Montgomery Ward & Co. of Chicago for $8.50 or $9.00. This is a very desirable bench, but a less expensive one, such as is furnished for manual training classes, will answer and will cost about $6.50.

List of Woodworking Tools.

Fore plane, 22 inch	$ 1.00
Jack plane, 16 inch	.70
Block plane, 6 inch	1.25
Rip saw, 5 teeth to the inch, 26 inch	1.38
Hand saw, 10 teeth to the inch, 26 inch	1.52
Back or tennon saw, 14 inch	1.27
Socket firmer chisels, ⅛ inch	.20
Socket firmer chisels, ¼ inch	.31
Socket firmer chisels, ½ inch	.35
Socket firmer chisels, ¾ inch	.42
Socket firmer chisels, 1 inch	.50

Socket gauges, beveled inside, ¼ inch	.40
Socket gauges, beveled inside, ⅝ inch	.50
Socket gauges, beveled inside, 1 inch	.60
Barber ratchet brace	.95
Set of Russel Jennings bits, set of 8	3.00
Syracuse bits, ⅛-5-16 by 32ds	.90
Rose countersink, ⅝	.21
Hatchet	.65
Claw hammer	.50
Riveting hammer, 8 oz	.50
Try square iron head, 6 inch	.20
Try square iron head, 10 inch blade	.50
Three brad awls, handled, different sizes	.25
Screw driver, 3 inch	.25
Screw driver, 6 inch	.35
Bevel, 8 inch blade	.20
Marking gauge	.10
Spring dividers, 6 inch	.80
Oilstone, Washita, mounted, 2 x6 inch	1.00
Oil can	.10
Two foot rule, brass bound	.50
Two wood handscrews, 12 inch, at 35c	.70
Barton draw knife, 8 inch blade	.90
Flat nose pliers, 6 inch	.45
Round nose pliers, 6 inch	.45
Total	$33.66

Iron Working Tools.

Hack saw, Starrett's adjustable	$ .90
One dozen 8 inch hack saw blades	.60
Cheney vise, 2½ inch jaws	2.75
Tinner's snips, 2½ inch cutting edge	1.75
Soldering copper, ½ lb	.40
Screw plate, dies and taps; machine screw, sizes Nos. 2, 4, 6, 8, 10, 12 and 14	4.00
Yankee spring calipers, 6 inch	.85
Broaches or reamers, 5 sided, 1-16 to 5-16	1.50
Centre punch, machinist's, ⅜	.15
File, double cut, 12 inch	.30
File, single cut, 8 inch	.20

File, single cut, 6 inch	.15
File, round, 6 inch	.15
File, round, 8 inch	.20
Cutting pliers, 6 inch	.75
Twist drill gauge	1.50
Breast drill	2.00
Total	$17.80

List No. 2.

Screw cutting lathe, 9 x 25	$48.75
U. S. chuck, two sets of jaws, fitted	6.00
Acme drill chuck, fitted	3.00
Set of turning tools for metal	1.50
Four lathe dogs	1.50
Hand rest	1.75
Spur centre for wood turning	1.50
Cup centre for wood turning	1.25
Screw chuck plate	1.25
Knurl, or milling tool	1.00
Turning chisel, ½ inch	.30
Turning chisel, ¾ inch	.35
Turning chisel, 1½ inch	.58
Turning gouge, ⅝ inch	.49
Turning gouge, 1 inch	.49
Total	$69.06

THE DENSITY OF A SOLUTION OF HYDROCHLORIC ACID.

By F. C. Irwin.

Central High School, Detroit.

This determination was suggested as a laboratory experiment by Prof. G. A. Hulett of the University of Michigan. Its main purposes are to emphasize with beginning students, first, that hydrochloric acid is a gas and second, that our reagent hydrochloric acid is a solution of the gas in water.

The experiment is worked after having devoted one laboratory and one recitation period each to the preparation and properties of

hydrochloric acid as generally studied. Provided with a balance accurate only to centigrams our students obtain uniformly accurate results. We provide the pupils with the following directions: Place in a weighed test tube about 5 cc. of distilled water and determine its weight. Mark the depth of water with a label. Next set the test tube in a dish of ice water and pass hydrochloric acid gas through the water in the test tube for about five minutes, keeping cold all the time. Now remove the delivery tube of the hydrochloric acid generator, note from the level of the liquid whether the volume of this solution is the same as the original volume of water. Wash off the label, wipe dry and determine the weight of the solution. Now mark the new level of the liquid, pour out this hydrochloric solution and fill the test tube with distilled water to the depth marked by the solution. Wash off label, wipe dry, and weigh again accurately. What is this weight of water? What was the weight of the equal volume of the hydrochloric acid solution? Compute the density of the solution.

We find that the experiment can be worked successfully in about sixty minutes. With a class of three sections numbering over one hundred students very few failed to find satisfactory results on the first trial. It may be noted that it is not necessary to obtain the weight of the original volume of 5cc of water, since the weight of water equal in volume to the hydrochloric solution is subsequently determined. The original volume of water, 5cc, increases usually to about 7cc, due partly to condensation of water vapor. We find it advantageous to treat the sodium chloride in the generating flash with concentrated sulphuric acid.*

The students who have worked this experiment are much better informed on the properties of hydrochloric acid than are students who have not made the quantitative determination.

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*A table of density and percent hydrochloric acid is instructive.

THE PHYSICAL NOTIONS OF ENTROPY AND FREE ENERGY AND THEIR IMPORTANCE IN GENERAL CHEMISTRY.*

By E. P. Schoch,

University of Texas, Austin.

The study of physics which teaches that energy relations determine the course and amount of physical changes naturally inclines the student of chemistry to the belief that energy relations play a similar part in chemical phenomena. The observation that chemical actions are frequently accompanied by evolution of heat naturally suggests that the amount of heat possibly evolved may serve as an indication of the direction of chemical reaction and may serve to measure the amount of change in any case. Facts show that *both* of these notions are wrong. Under certain conditions many reactions proceed in such a sense as to liberate heat while under other conditions they take place with absorption of heat. Though there are many reactions which proceed in such a sense as to evolve heat, it is due to the fact that the *conditions* which naturally obtain are such as to *produce* this result. On account of the predominance of the number of these cases chemists have accepted this "half truth" as the whole truth, and even now this erroneous notion is *current.*

Not only does the heat change not indicate the direction of chemical change, but it is not *in general* a measure of it. While for any *one* reacting mixture the amount of change is proportional to the amount of heat cooled (or absorbed) and for the reverse change the same proportional amount of heat will be absorbed (or evolved), yet for comparing the amounts of change among different substances the heat change does not serve as a measure except under certain conditions. These conditions frequently naturally obtain, and thus it has come about that this "half-truth" also is held by very many chemists as the "whole truth." Especially is this true among technologists, who for economic reasons need a measure of chemical changes in terms of energy. Practical electro-chemists constantly calculate the decomposition tension of electrolytes from the heats of formation, though the two quantities are but rarely the same. The error in this whole idea is

* Read before the Texas Academy of Science at Austin, Texas, January 20, 1905.

shown most strikingly by the following fact: Hydrogen gas changes to hydrogen ions unaccompanied by any heat changes. Here evidently the amount of chemical change is not measured by the amount of heat change.

But our science has not merely succeeded in negativing the early attempts in this direction—it has produced something in place of it. It is the object of this paper to indicate briefly and in as concrete a form as possible some of the most fundamental results which have been definitely established but which are usually expressed in abstract mathematical terms and hence are not "current."

Changes in physical bodies which may be produced or accompanied by the addition or abstraction of heat are measured in terms of *entropy*. At a glance it is seen that this includes all chemical changes. The addition or abstraction of heat may change the energy contents of the body, as, for instance, by changing the temperature of the body, or at certain points of temperature, the state of aggregation; thus at 0° C. ice changes to water on the addition of heat, etc.; or again, the addition or abstraction of heat may produce chemical changes, such as the decomposition—at high temperatures—of steam into hydrogen and oxygen. Thus a mixture of steam, hydrogen and oxygen, which is in equilibrium at 1,500° C. would, if cooled or heated, change to a mixture of different proportions, and *some* of the heat given out or taken up by the mixture would be produced by the union of hydrogen and oxygen or consumed in the decomposition of steam through which the mixture changed its composition. Furthermore, the addition of heat may cause the body to expand if the surroundings permit it. Thus the addition of heat to a gas confined in a cylinder closed at one end and at the other end provided with a movable piston against which a constant pressure is exerted will cause the gas to expand against the pressure on the piston. Thus work is done and energy expended.

Under what conditions must the change take place in order that a heat change externally observed may alone be effective in producing the change? To answer this question the effect of heat on a physical body must be considered in detail.

The heat received by a body may be retained as such, or it may be partly or wholly expanded while the volume energy increases. By this latter term is meant the product of the internal

pressure with which the body tends to expand, multiplied by the volume through which it expands.

The volume energy of a body would evidently change without expending any internal energy; thus a gas may expand into a vacuum; a salt may dissolve in a solvent where the expanding substance does not have to overcome any opposing pressure and hence no energy is used to do external work. But if the external pressure is just equal (in reality it must be slightly less) to the internal pressure then the external work done is equal to the volume energy change and hence the volume energy change equal to the internal energy consumed. Under these conditions the heat obtained from without is equal to the increase of internal energy plus the change in volume energy. Hence if a body is to undergo no change except that due to the addition of heat, then any volume change which it experiences must be under such conditions that the change in volume energy shall have consumed an equal amount of internal energy and that is the case only when the external confining pressure is just equal to the pressure with which the body tends to expand.

The volume change needs some special consideration. The volume to be considered is not merely that of the total mass, but rather the specific volume or concentration of each constituent which can vary its concentration independently of others. Thus a mixture of a salt and its saturated solution, which when heated to a higher temperature dissolves more salt, undergoes not only a change in external volume, but the additional salt dissolved changes from the volume occupied in the solid state to a much larger volume in the solution. Let us consider the change produced when heat is added under the condition that any volume change shall consume an equal amount of heat. First of all, we find that only heat which is at the temperature of the body can be considered in calculating the "amount of effect," because heat in surroundings which are at a lower temperature than the body does not flow into the body, and heat coming from surroundings which are at a higher temperature could do more than merely enter the body and its addition transform it: while falling in temperature the heat could produce work through the agency of a proper heat engine and yet when delivered from the engine at the temperature of the body it can enter it and change

it thereby. Thus it is seen that only heat at the particular temperature of the body is able to enter the body and *do nothing else.* The question arises: When a body has been changed by adding to it a quantity of heat, Q_1, at the temperature, T_1, how much heat must be taken away at any other temperature T_2 so that the body is changed back to its original state. To solve this, the considerations and results involved in Carnot's Cycle will be employed. These considerations may be found in any large text on physics. The result usually appears thus:

$$Q_1 - Q_2 = \frac{(T_1 - T_2)\, Q_1}{T_1}$$

The body operated upon in this case is a gas. During the changes the external pressure is constantly equal to the internal pressure—hence from the foregoing it is seen that the gas which receives Q_1 units of heat at T_1 constantly retains this energy either in the form of internal or volume energy until it gives up Q_2 at T_2. From this point on all remaining energy is retained, although it is changed partly from volume energy to internal energy or vice versa in equivalent amounts. At the end the gas is in its original state. The above formula readily simplifies to

$$\frac{Q_1}{T_1} = \frac{Q_2}{T_2}$$

Thus a gas that cannot change except through the heat added or abstracted experiences an amount of change expressed by $\frac{Q}{T}$ —a change produced by one $\frac{Q_1}{T_1}$ may be reversed by taking away any other quantity Q_2 at T_2 so related that

$$\frac{Q_2}{T_2} = \frac{Q_1}{T_1}$$

When the body is under such conditions Q is said to be its change in entropy. It may readily be shown what is thus true of a gaseous body is true of any solid or liquid body or mixture. The apparently queer part in the above is the fact that any external work done by or on the body does not produce a change in it and affect its entropy.

To consider the measurement of entropy on the body itself, let us take a mixture under such circumstances that outside of volume changes it does not give up energy in any form except

heat, but, contrary to the foregoing, with *no restriction upon the external pressure*. This is the case in most chemical reactions, because the volume energy change takes place entirely independently of the heat change, and may not even affect it or it may increase it or decrease it. Then the heat absorbed or evolved *minus* or *plus* the amount required for external work to change the volume, *plus* or *minus* the change in volume energy represents the total energy change, which as before, divided by T, gives the amount of change in entropy units. This may be written

$$\frac{Q - W + pdv}{T}$$

where Q is the heat received from the outside, W the external work done and pdv the change in volume energy. When the change extends through different temperatures the sum of all changes taking place at the different points of temperature must be considered.

Here $(Q - W)$ is the change in internal energy. When the change takes place under such conditions that $W = pdv$ (*i e.*, when the external pressure is equal to the internal pressure which is exerted to produce change of volume), then the expression correctly shows what was seen before—that the entropy change is due to Q only. But in general this condition does not obtain, and the entropy depends on both the total change of internal energy $(Q - W)$ plus the volume energy change, which latter, as shown above, may take place entirely or partly independently of the internal energy change. That this independent change in measure and effect is equal to a heat change, and hence the two added together determine the change in entropy, may be understood from the following examples: When a gas expands into a vacuum its temperature does not change, and hence its internal energy is unchanged. We say its volume energy has increased by pdv. But to bring the gas back to its former volume work in amount equal to pdv will have to be done to compress it. As a result of this work, the temperature of the gas rises corresponding to an increase of heat equal to pdv. Now, this compression is under such conditions (see above internal and external pressures practically equal) that the entropy can change only by the body's receiving or giving up heat as such to the surroundings. Hence the gas had the same entropy at the end

that it had just after expanding into the vacuum, and this value is plainly greater than its entropy value at the very beginning by the amount of volume energy change, *pdv*.

In many cases W and *pdv* are zero. Thus at 0° the change of ice to water is measured by the heat rendered latent. Again, when a gas expands into a vacuum, Q and W are zero and the change is measured by the increase in volume energy.

This means of measuring changes also takes care of such peculiar cases as the change of hydrogen to hydrogen ions. Here again Q and W are zero, but *pdv* measures the change.

The immense importance of the idea of entropy to the chemist probably justifies the length of the preceding statement, though it is not claimed that the presentation is more than a mere indication intended to help remove the notion that entropy is a mathematical quantity without physical meaning.

Side by side with this result that thermo-dynamics has produced for chemistry and which gives the *correct* notion in place of one of the two "errors" set forth in the introduction we shall present the corresponding result obtained in place of the other error—namely, an expression involving energy measurements which indicates the *direction* of possible change of a mixture. By far the greater number of chemical reactions take place practically at one particular temperature—isothermically and without the performance of external work. Under these conditions the heat evolved or absorbed practically represents the change in internal or total energy. The change in entropy involves in this case only one temperature, and multiplying the entropy by this T gives the latent energy which is absorbed or evolved during the change which added to or subtracted from the latent energy in the mixture before change gives the amount of latent energy necessary for the body to remain in the resulting state.

It has been found that the expression

$$(U_1 - U_2) - T(\Phi_1 - \Phi_2)$$

always gives a positive quantity whenever a mixture with the internal energy U_1 and entropy Φ_1 undergoes reaction, producing a mixture with the internal energy U_2 and entropy Φ_2. Hence any mixture which by reaction can produce a mixture of which the relation of the internal energies and entropics as per above expression gives a positive quantity is certain to react. This difference between changes in *total* and *latent* energies is

called *free* energy. At any one constant temperature reaction takes place only with the expenditure of free energy. Here, then, is a quantity derived from energy relations which indicates whether or not reactions may take place in a particular mixture.

With this expression it may be understood why reactions may take place with *absorption* of heat even. Such absorption of heat would make U_2 larger than U_1. Yet if Φ_2 is sufficiently larger than Φ_1 this negative quantity $(\Phi_1 - o_2)$ subtracted from the negative quantity $(U_1 - U_2)$ will still produce a positive difference.

The amount of free energy may be measured when the mixture reacts under certain conditions, and these measurements represent to a certain extent differences of chemical *potential.* These determinations have done service particularly in calculating the electromotive force of battery cells. It is ordinarily assumed that the electrical energy obtainable from a certain battery cell may be calculated from the heat of reaction of the compounds of the cell. This is an error. In some cases more electrical energy is obtainable, in others less, than corresponds to the heat evolved. However, the electrical energy is equal to the *free* energy. In all cases the free energy is a measure of the maximum work obtainable from a chemical reaction. Hence its value! The importance of the conception of *free* energy in general chemistry has been acknowledged by as great an authority as Ostwald, who sets it forth in his " Principles of Inorganic Chemistry."

EXPERIMENTS WITH DYES.

By Warren R. Smith,
Lewis Institute, Chicago.

Having recently had occasion to show some simple experiments illustrating the general principles of dyeing, I was unable to find definite directions for the same and was obliged to make a number of trials before obtaining satisfactory results. I give below directions for a number of experiments which I found to work very well. It is probable that these directions could be improved, but they are fairly satisfactory in their present form and may be of advantage to some one who has not the time to work out better experiments.

In the first place, a number of points may be shown with ordinary inorganic reagents. The action of a mordant is very well illustrated by dipping a piece of cotton cloth in a solution of potassium dichromate and showing that the color is readily washed out, and then dipping a similar piece of cloth which has been soaked in lead acetate solution in the same dichromate solution. This gives yellow lead chromate, which, being insoluble, cannot be washed out of the cloth. The production of a color by oxidation may be shown by treating cotton cloth first with manganous chloride solution and then with sodium hydrate solution, rinsing and exposing to the air. The cloth will be dyed brown by the oxidation of the manganous hydroxide. The same result may be attained more rapidly by dipping the cloth, after treating with manganous chloride, in a solution of bleaching powder which will simultaneously precipitate and oxidize the manganous compound. All the above solutions may be of the ordinary reagent strength.

With organic dyes a more varied line of experiments may be shown. The difference in the action of dyes on animal and vegetable fibres may be shown with almost any dye, including those which, like methyl orange, are usually on hand in the laboratory for use as indicators. I have used malachite green and eosin, as they serve to illustrate another point as well. If pieces of cotton and of woolen cloth are treated with 0.5% solutions of these dyes for one minute at a temperature a little below 100° the wool will be found to have acquired a decided color, while the cotton has comparatively little after washing. Very likely greater differences could be obtained by using a more dilute solution for a longer time, but the rapidity of the action is an advantage for lecture table work. The same two dyes may be used to show the action of basic and acid dyes on cloth treated with basic and acid mordants. If two pieces of cotton cloth are soaked, the one in tannic acid solution, the other in sodium stannate solution and then in alum solution, it will be found that the one treated with the tannic acid will be dyed by the basic malachite green and unaffected by the acid eosin, while the reverse will be true of that treated with the basic mordant.

Reduction to the colorless leuco dye and subsequent oxidation is well shown with indigo. If 2 grams of indigo powder, 5 grams of zinc dust and 10 grams of slaked lime are mixed with 200 c.c.

of water in a stoppered bottle, in a short time the indigo will go into solution as the colorless indigo white. If a piece of cloth is dipped in this solution and then rinsed and exposed to the air it will soon acquire a fine blue color.

The action of a polygenetic dye may be shown on the mordanted cloth, which can be obtained from any dealer in chemical supplies. This acquires several different shades if boiled for some time in water to which a small amount of alizarin has been added. The action is more rapid if a quantity of ammonia insufficient to dissolve all the alizarin is added to the water. Other experiments which may be shown if the dyes are available are the formation of alizarin blue on heating and the action of any of the direct cotton dyes.

THE VOLUMETRIC COMPOSITION OF WATER VAPOR.*

By George A. Hulett,

University of Michigan.

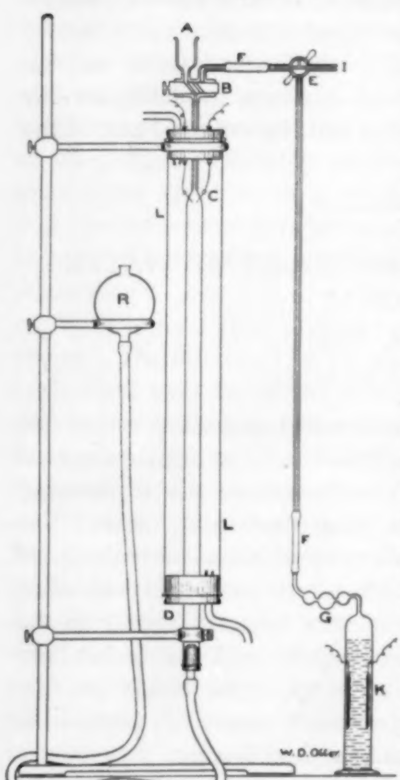
The volumetric relations of interacting gases and vapors are of fundamental importance in our atomic and molecular theories, and Hofmann has done a very considerable service in devising many experiments to demonstrate these fundamental facts. But the experiment as commonly performed to show the volumetric composition of water vapor is difficult to carry out and most frequently fails, as water vapor is very liable to appear in the eudiameter tube where steam is passed through the jacket, and then it is necessary to dismantle the apparatus before another trial. This and other difficulties frequently necessitate postponing the experiment and discussion until the next lecture.

I have used for several years an apparatus that gives very satisfactory results, and have been asked to describe the experiment. The apparatus allows one to repeat the experiment without dismantling or even stopping the steam in the heating jacket, and has the advantage of an adjustable mercury reservoir, which is joined by a rubber tube to the straight eudiometer tube. The essential feature of the method is a capillary tube sealed to the top of the eudiometer tube and extending outside the steam

*A lecture experiment.

jacket. Water vapor can be removed through this tube, so it is not necessary to dry the mercury or tube before setting up the apparatus. The detonating gas mixture (2 vol. H and 1 vol. O) is also introduced through the capillary and then capillary is filled with mercury, closing it at the point where it is sealed into the eudiometer tube and inside the steam jacket.

The accompanying figure gives a drawing of the essential parts of the apparatus. (L L) is a glass jacket some 5 x 60 cm., closed with split corks, which bear the graduated eudiometer tube (C D), $1\frac{1}{2} \times 65$ cm. This tube is provided at C with the usual platinum wires and well insulated leads, which are joined to a Rhumkorff coil for exploding the gas mixture. At C is sealed on a capillary (1mm bore) tube, 12cm long and ending in the two-way cock B. This cock (B) communicates with the little mercury reservoir A, or through the tube (F) to the exit (I), or down to the detonating gas generator (K), depending on the position of the three-way cock (E). K, the detonating gas generator, is some $2\frac{1}{2}$ x 15 cm., provided with small platinum electrodes, the generator is provided at G with sulphuric acid drying bulbs. At FF are rubber joints to make the apparatus flexible. (With a little skill in glass blowing one can make a very cheap generator from a glass tubing, leaving the bottom of the generator open for a cork, which carries two nickel electrodes.) It is best to use a 15% solution of caustic soda or caustic potash in the generator to avoid the formation of ozone. An ampere current will yield about 12 cc. of detonating gas per minute and about 4 volts is necessary for this purpose with the above generator. A convenient switch is needed in the battery



circuit to make and break the generating current at will. The generator must be allowed to run long enough to remove all air from the generator, dryer, etc., through the cocks and exit (I). R is an adjustable mercury reservoir, held in a three-quarter ring, which allows of its being removed for rapid lowering and raising. The jacket is heated by steam from a large flask of boiling water. The exit is below and if other vapors than steam are used for higher temperature a condenser is attached to the lower outlet.

After the apparatus is set up and steam begins to pass through the jacket, water vapor may appear in the eudiometer tube. To remove this the cocks B and E are turned so as to communicate with the exit (I) and by raising and lowering the reservoir several times the vapor is swept out by the air that is drawn in and forced out. The generator is now started and the cock E turned to bring the gases into the apparatus. After some of the gases have been introduced into the eudiometer tube it is well to turn the cock E and force them out through I and then fill for the experiment. When the desired volume of detonating gas is introduced the battery circuit is broken and the cock B is turned to communicate with the little reservoir (a), filling the capillary with mercury and closing the eudiometer tube off at C. The cock B is then closed. The volume of detonating gas is measured and after leaving the reservoir to rarify the gases they are exploded and the resulting volume of vapor measured. The experiment can be repeated in a very short time, first removing the vapor as above described.

The lead wires must be well insulated to insure a spark at the platinum points. It is well to have one at least pass through a small glass tube in the upper cork. If steam is used in the jacket it will be necessary to measure the vapor formed under diminished pressure, for the water vapor deviates considerably from the gas laws. At the boiling point of water one can easily measure all volumes under diminished pressure by keeping the reservoir a definite, measured distance below the mercury in a eudiometer tube. If it is considered more desirable to measure the gases and vapor at atmospheric pressure one may use amyl alcohol, giving a temperature of about 130°, and then a condenser is to be used for the outlet. With a little skill in glass blowing one can easily construct the above apparatus, as the cocks used are commonly at hand.

Such an apparatus was exhibited at the last meeting of the Michigan Schoolmasters' Club, and gave as a result 20.8 cc. detonating gas and 14.05 water vapor, and many of the results are even better than this.

AN APPARATUS FOR ILLUSTRATING THE EQUALITY OF EXPANSION OF DIFFERENT GASES.*

By C. F. Adams.
Central High School, Detroit.

The apparatus here described is intended to illustrate before a class that different gases expand equally under similar conditions. It consists essentially of two air-thermometers of equal size supported upon a wooden standard as shown in Fig. 1. The bulbs of these thermometers are two small flasks of about 100 cc. capacity.

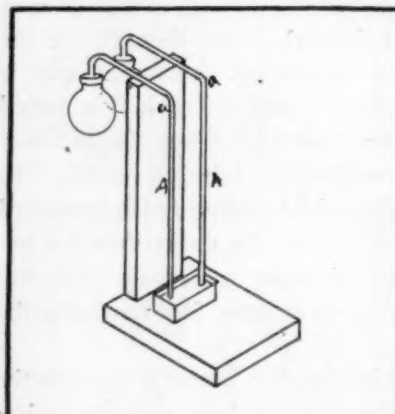


FIG. 1

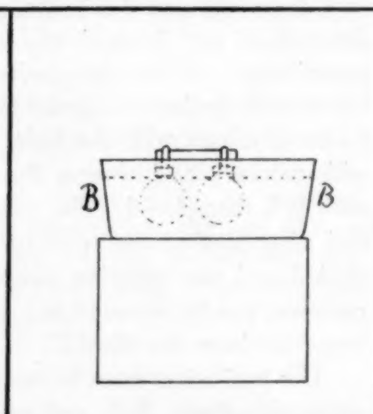


FIG. 2

The capacities of these flasks were first tested to see that they were equal and marks made upon their necks with a file to show how far the stoppers should be inserted to maintain the equality. About 3 cc. of sulphuric acid are placed in each flask to keep the gases dry. The vertical part of the stems of the thermometers, A A, consists of a small slim pipette or burette graduated in tenths of a cubic centimeter from 0 to 5 cc. They were selected so that the lengths of the graduated parts are equal and the zero marks

*Read before the Physical Conference of the Michigan School Masters' Club, April 1, 1905.

equally distant from the end. These pipettes, inverted, are connected to the flasks by glass tubing bent as shown in the figure. The union at *a a* may be made by rubber tubing, but it is an easy matter to fuse the pipettes to the tubing and the apparatus is more permanent and there is less danger of leakage. Care should be taken to have the bottoms of the two flasks at the same level and the lower ends of the pipettes should also be at the same level. These dip into a beaker containing concentrated sulphuric acid. Commercial acid should be used since it can be easily seen in the tubes at a distance.

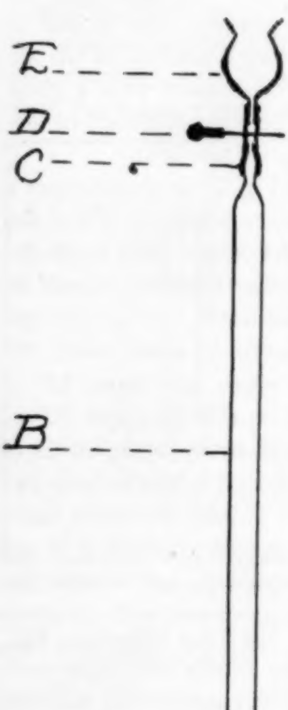
The flasks are closed by stoppers having two holes. After the apparatus is set up one of the flasks is filled with hydrogen or other gas by inserting a delivery tube of a gas generator in one of the holes of the stopper and gas passed through until all of the air is expelled. The hole in the stopper is then closed with a glass plug. The other flask is filled with air. The chief difficulty in setting up the apparatus is in making it perfectly air-tight.

In using it a large basin of water B B (Fig. 2) is placed upon a box at such a height that when the flasks are placed in it and the wooden support rests on the table, the flasks do not quite touch the bottom of the basin. The support for the thermometers should be heavy enough to hold the flasks down in the water. Before the apparatus is used the flasks should be placed in water about 10° warmer than will be used in the class room, say about 45° C. Thus some of the gases will be expelled so that at about 20° C. the acid will stand near the top of the graduation in the stems of the thermometers. For the actual experiment it is best to have two basins, one containing water at about 20° C. and the other water at about 35° C. The flasks can then be placed alternately in one basin and then in the other and the expansion and contraction noted. It will be readily seen that the experiment will take very little time in the class and that it can be repeated with very little trouble.

SIMPLIFIED APPARATUS FOR THE DETERMINATION OF THE VOLUMETRIC COMPOSITION OF AMMONIA.

BY LINUS S. PARMELEE.
Flint High School, Michigan.

This experiment can be performed with such simple apparatus that the most meagerly equipped laboratory can furnish it. Any kind of a tube can be used. One with an internal diameter of about 9 cm. and from 40 to 60 cm. long will give splendid results.



Suppose the tube is a plain burette (B). Fit the large end with a rubber stopper (A) and the other end with a short piece of rubber tubing (C) and a pinch clamp (D). Close the clamp (D) and fill the burette with chlorine by displacement of water. Be sure that the tube is filled with *chlorine*. When the tube is full, lower it in the trough and pinch the clamp for an instant to let the increased pressure drive the water out of the small part of the tube.

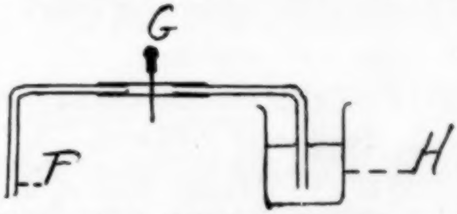
Allow the apparatus to stand (5 minutes) till the water in the burette runs down. If the tube is not now full, add chlorine.

Insert the stopper (A) and push it in firmly. (Be careful not to warm the gas by handling the tube.) Pinch the clamp an instant to equalize the pressure. The burette is now full of chlorine at room temperature and pressure.

Clamp the tube in a vertical position and insert a short-stemmed thistle tube (E) in the rubber tube at the top. Pour 10 cm.^{3} of strong ammonia water into the thistle tube. Work a glass rod up and down in the stem of the thistle tube to

remove air bubbles. Let the ammonia drop slowly into the chlorine (by pinching the clamp) till nearly all is used. Remove the thistle tube and tilt the burette to completely use the chlorine.

Connect the burette with a small beaker (H) of diluted sulphuric acid (1:4) by a bent tube (F) filled with water. Be sure there are no air bubbles in any of the connections. (The clamp (G) holds the water in the arms of the tube while the connection is made.) Remove the clamp (G) of the tube and pinch the clamp (D) of the burette and allow the acid of the beaker (H) to flow in. Close the clamp and allow the apparatus to cool to room temperature. Again pinch the clamp. Disconnect the tube (F).



Measure the length of the liquid column. Invert the tube and measure the length of the gas column. The sum of these lengths is the length of a chlorine column of uniform diameter whose volume is the original volume. Examine the gas.

As the volume of chlorine used up is equal to the volume of hydrogen furnished by the ammonia, and the nitrogen originally with this hydrogen is the remaining gas, the ration is easily seen.

Students easily determine the ratio correct to 5 mm. of nitrogen, using a burette, and often much more accurately.

NOTE ON FILLING A BAROMETER TUBE.

By N. F. Smith,
Olivet College, Olivet, Mich.

The problem of successfully filling a barometer tube with mercury is one which has caused difficulty to many teachers, and the following method, which has been successfully used many times, may be found helpful.

The tube, about eighty centimeters long and at least six millimeters in diameter, is sealed at one end and then placed in a vertical gas pipe an inch or more in diameter provided with a cap or plug at the lower end. The gas pipe is then filled with sand, leav-

ing the barometer tube projecting about an inch from its center. A short piece of large glass tubing is fitted to the upper end of the barometer tube with a rubber stopper. Pure mercury is now poured into the barometer tube and allowed to stand at a height of an inch or more in the large tube at the top. Four or five Bunsen burners are clamped at various heights beside the gas pipe and the whole thing heated till the mercury has boiled for some minutes. A piece of iron wire worked up and down in the tube aids in removing the air bubbles. After the whole apparatus has cooled the tube may be removed and inserted in the usual manner. The height of the mercury in the tube will be found to differ very little from the reading of the standard barometer.

A NEW FORM OF CELL.

By Walter P. White.

Carnegie Institution Geophysical Laboratory, Washington, D. C.

The story is tolerably well known of the diagram of an impossible iceberg, published some years ago in a text-book of high rank. It may have been a rational diagram, shortened to save space, or an out-and-out blunder in the beginning. At any rate, it was unthinkingly copied by other high authorities., until it attained a position on the cover of a widely used work.

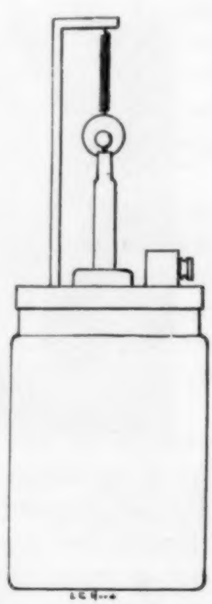
The tendency to copy mistakes and anachronisms is often seen in apparatus—among others, in the case of the bichromate, plunge, or Grenet batteries. These batteries usually consist of a flat zinc plate, set between and close to two carbon plates. The numerous disadvantages of this plan are easily seen. The zincs are awkward to handle, and unnecessarily difficult to amalgamate. When worn out, as they very frequently are, their replacement is troublesome and expensive. And especially, the surface exposed to the solution is too large, so that there is more local action than there need be. This is wasteful, and the solution needs frequent renewal.

The reason for the inconvenient construction is, of course, plain enough. The resistance is thereby made very small. The exceedingly low resistance, however, is not necessary, and is by no means worth its cost. This is due to the fact that it is polarization which forms the effective limit to the current in these

cells. The cell will run down hopelessly unless the external resistance is so high that the very low internal resistance becomes a matter of no consequence.

It follows that these frail, troublesome and expensive batteries are in every way inferior to the ordinary carbon cell, when it is supplied with amalgamated zinc and chromic acid solution. The zincs are easy to amalgamate and keep clean, and can be replaced in any town at nominal cost. The solution lasts much longer, and is protected from dust and evaporation. This form of bichromate battery has only one serious disadvantage. The acid solution often corrodes the binding post which is clamped on the carbon. This trouble can be prevented by a small, very thin washer of gold or platinum. It is equally likely to occur with other forms of bichromate battery, where the surface to be protected from the acid is greater.

The idea of filling a carbon cell with bichromate solution is not new, though its value seems still to need pointing out. The chief object of the present article, however, is to call attention to a device for supporting the zinc in such cells. This is shown in the figure. A rod is fixed in the carbon, and the zinc is attached to this by an insulating support and a spiral spring. The zinc in such a battery can be used as a key to close the circuit, and is drawn up by the spring when the current is no longer needed. The zinc is thus exposed to the wasteful action of the strong acid only for the actual time of taking current, and in particular is not likely to be left in the solution for long periods through forgetfulness. The average life of a charge of acid and zinc is so much increased as to make a very great difference in the value of this type of cell to a busy teacher or laboratory assistant. The quickness with which the zinc is raised and lowered, and the fact that it can be done with one hand, where the usual plunge battery requires two, make this form of cell very convenient, especially for class demonstra-



tion. When more than one cell is to be used at a time they can all be worked in unison by running a wooden rod through the rings by which the springs are attached to the zincs.

Cells of the type here described are, perhaps, even more valuable in the laboratory than in the lecture room. For fairly strong currents they are about as steady as copper sulphate batteries, and enormously cheaper and less troublesome, and wherever the extreme steadiness of the storage or Edison battery is not demanded their convenience and low cost of maintenance have made them, in the writer's opinion and experience, the best battery for most high school laboratory work.

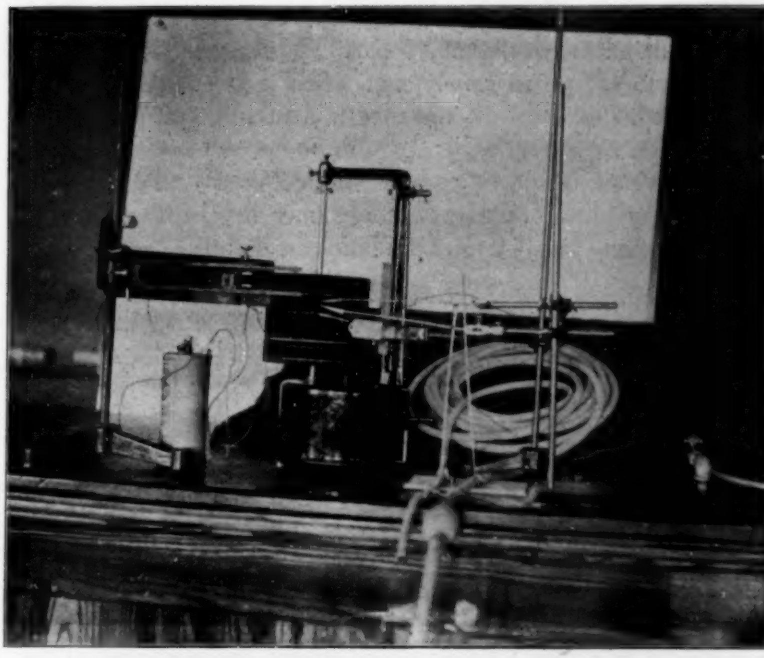
AN EXPERIMENT TO DEMONSTRATE THAT THE PULSE IS CAUSED BY A WAVE OF PRESSURE AND IS NOT DUE TO THE ONWARD FLOW OF THE BLOOD.

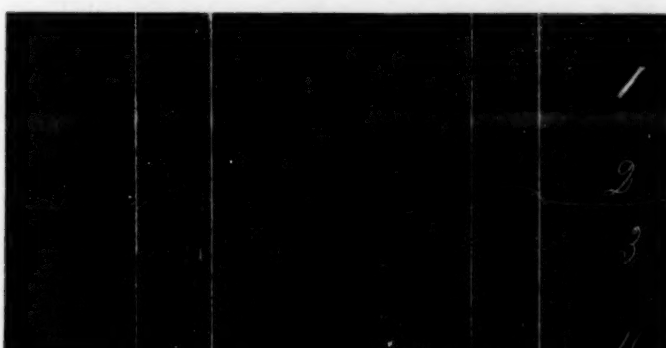
By S. D. Magers, M. S.
State Normal College, Ypsilanti, Mich.

To demonstrate that the pulse is due to a wave of pressure and not to the onward flow of the blood, these two facts must be understood by the student: First, that the tension of the walls of the arteries makes their contained blood fill them completely. Second, that with each ventricular systole, about five ounces of blood are forced into the already filled aorta.

To show that this influx of blood causes increased pressure on the walls of the aorta at its base and that this starts a wave of pressure traveling with great rapidity toward the capillaries, causing an expansion of the arteries in its course, a pulse wave, the following apparatus is devised: A drum kymograph, two time-markers, a rubber tube with syringe bulb at one end, a jar of water and two pulse recording levers.

The kymograph of the type shown in the illustration has the paper of its drum smoked, the drum making nearly four revolutions per minute. The seconds time marker, making the lowest line (4), is controlled by a pendulum, within an electric circuit, vibrating through a drop of mercury to make and break the circuit at second intervals. The other time marker, making the uppermost line (1), consists of a tuning fork, also within an





electric circuit, vibrating one hundred times per second, so adjusted that one arm with a thin, sharp pointed spring records one-hundredth seconds on the drum. The rubber tube, twenty-five feet in length, a half inch in diameter, coiled to take up less room, has at one end a syringe bulb provided with two valves,

representing the ventricle, for pumping water into tube from the jar. The distal end of the tube is partially plugged. This permits the water to escape so slowly that when it is pumped into the tube by means of the bulb, the tube is kept full, and pressure is exerted upon its sides.

Two levers with paper pens for recording on the drum were supported by beams resting on the rubber tube, the one at the bulb end making line (2) and the other on the distal end making line (3).

Under these conditions, with each compression of the bulb a

(1) Line made by 1/100 seconds time-marker.
(2) Line made by lever resting on bulb end of tube.
(3) Line made by lever resting on the distal end of tube.
(4) Line made by seconds time-marker.

given amount of water is added to the already filled tube, starting a wave of pressure at the bulb, traveling to the distal end of the tube, expanding it in its course.

TO SHOW THE VELOCITY OF THE WAVE.

By placing the tip ends of the pens of the two levers and that of the one-hundred seconds time-marker in a vertical line against the rotating drum, the time elapsing between the beginning of the expansion at the bulb end and the beginning of the expansion at the distal end is recorded in one-hundredth seconds. It will be observed that the line (2), made by the lever whose support rests upon the bulb end begins to rise only about twenty-four hundredths (24-100) of a second before the lever resting upon the distal end of the tube, making line (3), showing that the wave travels nearly twenty-five feet in twenty-four hundredths of a second.

TO SHOW THE VELOCITY OF THE BLOOD.

Some eosin solution is injected into the rubber tube at the bulb end by a hypodermic syringe at a time a hard compression of the bulb is made. (The strong compression being made to cause the levers to rise unusually high to indicate the time of the injection). The bulb is compressed regularly and evenly thereafter. It is found that it takes about thirty-five seconds for the eosin to reach the distal end of the tube. Thus demonstrating that before the eosin reaches the distal end of the tube 145 pulse waves have passed over the full length of the tube. That while the eosin travels *five-sevenths* of a *foot* per second the

pulse wave travels *104 feet* per second. Thus demonstrating that the pulse is a rapidly moving wave of pressure, while the blood lags far behind.

It might be added that these facts may be demonstrated quite clearly *without* the use of kymograph or time-markers by simply observing the almost synchronous movement of the levers and the long time elapsing between the injection and the outpour of the eosine.

The next person to hold the Rhodes scholarship from Illinois is Mr. Newton Ensign, of McKendree College. He will take the honour course in mathematics at Oxford. Mr. Newton was prepared very largely for this scholarship by Prof. G. W. Greenwood, of McKendree College.

A CORRECTION.

In the article by William H. Snyder on "Map Construction" there is a mistake in the construction of figure 3 on page 33 of the current volume of this journal. The line A D should pass through the point K; that is, there should be one more line drawn from the point A. The tangent line B D is divided into nine parts, the same as the quadrant W. S. The mistake was made by the draughtsman who prepared the drawings for the engraver and is one for which neither Mr. Snyder nor the present editor of the section is responsible.

NOTES FROM THE UNIVERSITY OF ILLINOIS.

Dr. A. T. Lincoln, assistant professor of chemistry, addressed the Mathematical Club on April 15 upon "Some Applications of Mathematics to Chemical Statics and Dynamics."

Mr. Lewis Omer, '02, instructor in mathematics in the Oak Park Township High School, on April 29, presented to the Mathematical Club a paper on "The Problems of the Young Teacher." Mr. Omer ranks among the best teachers of secondary mathematics in the state and his discussion of the problems which he had met in his own experience proved him a forcible, level-headed enthusiast in his subject with an appreciation of the difficulties of his students.

Prof. A. N. Talbot, professor of municipal and sanitary engineering, on May 2, presented to the society of Sigma Xi a paper on "Reinforced Concrete." The results of Prof. Talbot's recent investigations on reinforced concrete have been published in "Bulletin No. 1 of the University of Illinois Engineering Experiment Station."

Mr. H. W. Reddick has been appointed fellow in mathematics for next year. Mr. Reddick is a graduate of the Indiana University and for the past year has been instructor in mathematics in the University of Illinois Academy.

ERNEST B. LYTLE.

OSTWALD'S METHOD OF OBTAINING X IN $X = R \frac{a}{1-a}$

When pupils are determining resistance by means of the slide wire bridge, time and labor are saved by using the following table which contains the values of $\frac{a}{1-a}$ for all values of a from 0.001 to 0.999 meters. To assist in understanding the process a diagram of apparatus and connections is shown. To obtain X find the value of $\frac{a}{1-a}$ in the table and multiply it by the known resistance R.*

a	0	1	2	3	4	5	6	7	8	9
00	0·0000	0010	0020	0030	0040	0050	0060	0071	0081	0091
01	0101	0111	0122	0132	0142	0152	0163	0173	0183	0194
02	0204	0215	0225	0235	0246	0256	0267	0278	0288	0299
03	0309	0320	0331	0341	0352	0363	0373	0384	0395	0406
04	0417	0428	0438	0449	0460	0471	0482	0493	0504	0515
05	0526	0537	0549	0560	0571	0582	0593	0605	0616	0627
06	0638	0650	0661	0672	0684	0695	0707	0718	0730	0741
07	0753	0764	0776	0788	0799	0811	0823	0834	0846	0858
08	0870	0881	0893	0905	0917	0929	0941	0953	0965	0977
09	0989	1001	1013	1025	1038	1050	1062	1074	1087	1099
10	0·1111	1124	1136	1148	1161	1173	1186	1198	1211	1223
11	1236	1249	1261	1274	1287	1299	1312	1325	1338	1351
12	1364	1377	1390	1403	1416	1429	1442	1455	1468	1481
13	1494	1508	1521	1534	1547	1561	1574	1588	1601	1614
14	1628	1641	1655	1669	1682	1696	1710	1723	1737	1751
15	1765	1779	1793	1806	1820	1834	1848	1862	1877	1891
16	1905	1919	1933	1947	1962	1976	1990	2005	2019	2034
17	0·2048	2063	2077	2092	2107	2121	2136	2151	2166	2180
18	2195	2210	2225	2240	2255	2270	2285	2300	2315	2331
19	2346	2361	2376	2392	2407	2422	2438	2453	2469	2484
20	2500	2516	2531	2547	2563	2579	2595	2610	2626	2642
21	2658	2674	2690	2707	2723	2739	2755	2771	2788	2804
22	2821	2837	2854	2870	2887	2903	2920	2937	2953	2970
23	2987	3004	3021	3038	3055	3072	3089	3106	3123	3141
24	0·3158	3175	3193	3210	3228	3245	3263	3280	3298	3316
25	3333	3351	3369	3387	3405	3423	3441	3459	3477	3495
26	3514	3532	3550	3569	3587	3605	3624	3643	3661	3680
27	3699	3717	3736	3755	3774	3793	3812	3831	3850	3870
28	3889	3908	3928	3947	3967	3986	4006	4025	4045	4065
29	0·4085	4104	4124	4144	4164	4184	4205	4225	4245	4265

* Copies of the above tables may be had, by addressing the Business Manager, for $1.50 per hundred, postpaid, or 25 cents for ten.

a	0	1	2	3	4	5	6	7	8	9
30	4286	4306	4327	4347	4368	4389	4409	4430	4451	4472
31	4493	4514	4535	4556	4577	4599	4620	4641	4663	4684
32	4706	4728	4749	4771	4793	4815	4837	4859	4881	4903
33	4925	4948	4970	4993	5015	5038	5060	5083	5106	5129
34	0·5152	5175	5198	5221	5244	5267	5291	5314	5337	5361
35	5385	5408	5432	5456	5480	5504	5528	5552	5576	5601
36	5625	5650	5674	5699	5723	5748	5773	5798	5823	5848
37	5873	5898	5924	5949	5974	6000	6026	6051	6077	6103
38	0·6129	6155	6181	6208	6234	6260	6287	6313	6340	6367
39	6393	6420	6447	6475	6502	6529	6556	6584	6611	6639
40	6667	6695	6722	6750	6779	6807	6835	6863	6892	6921
41	6949	6978	7007	7036	7065	7094	7123	7153	7182	7212
42	0·7241	7271	7301	7331	7361	7391	7422	7452	7483	7513
43	7544	7575	7606	7637	7668	7699	7731	7762	7794	7825
44	7857	7889	7921	7953	7986	8018	8051	8083	8116	8149
45	0·8182	8215	8248	8282	8315	8349	8382	8416	8450	8484
46	8519	8553	8587	8622	8657	8692	8727	8762	8797	8832
47	8868	8904	8939	8975	9011	9048	9084	9121	9157	9194
48	0·9231	9268	9305	9342	9380	9418	9455	9493	9531	9570
49	9608	9646	9685	9724	9763	9802	9841	9881	9920	9960
50	1·000	1·004	1·008	1·012	1·016	1·020	1·024	1·028	1·033	1·037
51	1·041	1·045	1·049	1·053	1·058	1·062	1·066	1·070	1·075	1·079
52	1·083	1·088	1·092	1·696	1·101	1·105	1·110	1·114	1·119	1·123
53	1·128	1·132	1·137	1·141	1·146	1·151	1·155	1·160	1·165	1·169
54	1·174	1·179	1·183	1·188	1·193	1·198	1·203	1·208	1·212	1·217
55	1·222	1·227	1·232	1·237	1·242	1·247	1·252	1·257	1·262	1·268
56	1·273	1·278	1·283	1·288	1·294	1·299	1·304	1·309	1·315	1·320
57	1·326	1·331	1·336	1·342	1·347	1·353	1·358	1·364	1·370	1·375
58	1·381	1·387	1·392	1·398	1·404	1·410	1·415	1·421	1·427	1·433
59	1·439	1·445	1·451	1·457	1·463	1·469	1·475	1·481	1·488	1·494
60	1·500	1·506	1·513	1·519	1·525	1·532	1·538	1·545	1·551	1·558
61	1·564	1·571	1·577	1·584	1·591	1·597	1·604	1·611	1·618	1·625
62	1·632	1·639	1·646	1·653	1·660	1·667	1·674	1·681	1·688	1·695
63	1·703	1·710	1·717	1·725	1·732	1·740	1·747	1·755	1·762	1·770
64	1·778	1·786	1·793	1·801	1·809	1·817	1·825	1·833	1·841	1·849
65	1·857	1·865	1·874	1·882	1·890	1·899	1·907	1·915	1·924	1·933
66	1·941	1·950	1·959	1·967	1·976	1·985	1·994	2·003	2·012	2·021
67	2·030	2·040	2·049	2·058	2·067	2·077	2·086	2·096	2·106	2·115
68	2·125	2·135	2·145	2·155	2·165	2·175	2·185	2·195	2·205	2·215
69	2·226	2·236	2·247	2·257	2·268	2·279	2·289	2·300	2·311	2·322

a	0	1	2	3	4	5	6	7	8	9
70	2·333	2·344	2·356	2·367	2·378	2·390	2·401	2·413	2·425	2·436
71	2·448	2·460	2·472	2·484	2·497	2·509	2·521	2·534	2·546	2·559
72	2·571	2·584	2·597	2·610	2·623	2·636	2·650	2·663	2·676	2·690
73	2·704	2·717	2·731	2·745	2·759	2·774	2·788	2·802	2·817	2·831
74	2·846	2·861	2·876	2·891	2·906	2·922	2·937	2·953	2·968	2·984
75	3·000	3·016	3·032	3·049	3·065	3·082	3·098	3·115	3·132	3·149
76	3·167	3·184	3·202	3·219	3·237	3·255	3·274	3·292	3·310	3·329
77	3·348	3·367	3·386	3·405	3·425	3·444	3·464	3·484	3·505	3·525
78	3·545	3·566	3·587	3·608	3·630	3·651	3·673	3·695	3·717	3·739
79	3·762	3·785	3·808	3·831	3·854	3·878	3·902	3·926	3·950	3·975
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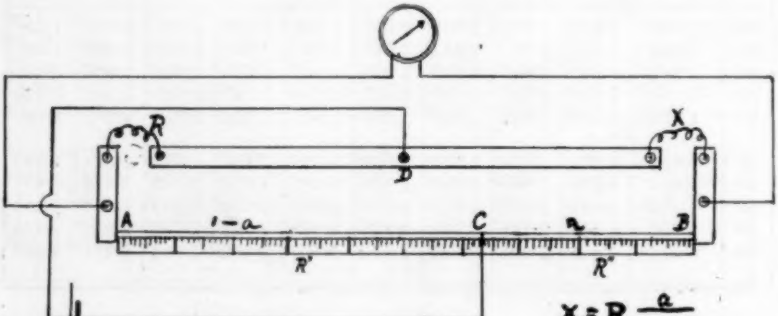
81	4·263	4·291	4·319	4·348	4·376	4·405	4·435	4·465	4·495	4·525
82	4·556	4·587	4·618	4·650	4·682	4·714	4·747	4·780	4·814	4·848
83	4·882	4·917	4·952	4·988	5·024	5·061	5·098	5·135	5·173	5·211
84	5·250	5·289	5·329	5·369	5·410	5·452	5·494	5·536	5·579	5·623
85	5·667	5·711	5·757	5·803	5·849	5·897	5·944	5·993	6·042	6·092
86	6·143	6·194	6·246	6·299	6·353	6·407	6·463	6·519	6·576	6·634
87	6·692	6·752	6·813	6·874	6·937	7·000	7·065	7·130	7·197	7·264
88	7·333	7·403	7·475	7·547	7·621	7·696	7·772	7·850	7·929	8·009
89	8·091	8·174	8·259	8·346	8·434	8·524	8·615	8·709	8·804	8·901
90	9·000	9·101	9·204	9·309	9·417	9·526	9·638	9·753	9·870	9·989
91	10·11	10·24	10·36	10·49	10·63	10·77	10·90	11·05	11·20	11·35
92	11·50	11·66	11·82	11·99	12·16	12·33	12·51	12·70	12·89	13·08
93	13·29	13·49	13·71	13·93	14·15	14·38	14·63	14·87	15·13	15·39
94	15·67	15·95	16·24	16·54	16·86	17·18	17·52	17·87	18·23	18·61
95	19·00	19·41	19·83	20·28	20·74	21·22	21·73	22·26	22·81	23·39
96	24·00	24·64	25·32	26·03	26·78	27·57	28·41	29·30	30·25	31·26
97	32·33	33·48	34·71	36·04	37·46	39·00	40·67	42·48	44·45	46·62
98	49·00	51·6	54·6	57·8	61·5	65·7	70·4	75·9	82·3	89·9
99	99·0	110	124	142	166	199	249	332	499	999



$$x = R\frac{a}{1-a}$$

A DISCUSSION OF GENERAL METHOD IN HIGH SCHOOL BOTANY.*

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This paper does not pretend to the completeness that its title suggests. It is rather an attempt to discuss the following questions, prepared by the committee on the program:

"How much and what can be done in ecological and physiological botany in the high school?"

"What divisions of physiological botany are best adapted for high school work?"

"To what extent can the scientific method be used?"

"Can field excursions be organized, and what are the benefits to be derived from them?"

"Should work begin with the use of the microscope and apparatus for experimental physiology, or should the instruments be introduced as the eye and the hand become more efficient?"

"Should the pupil be required to bring together the results of his study along a given line in the form of tables, curves, etc?"

The ideal botany course, it is generally conceded, should include all of the great leading divisions of the subject, anatomy, morphology, physiology, ecology, and systematic botany.

The answer to this question should depend somewhat upon the place the subject occupies in the school course. The earlier it is placed in the curriculum the more the work should deal with the activities of plants, their relations to their environment, and their identification, and the less with details of anatomy and morphology. Of all the benefits that the study of botany may confer upon the pupil, none, I venture to say, is greater than the abiding interest which it should create in him in the world in which he lives, in the manifestations of life by which he is ever surrounded. How often botany will accomplish this end will depend upon the extent to which it is adapted to the pupil's stage of development. First-year pupils are much more interested in a plant's life than in its anatomy, care far more for knowing the names of things and where and how they live, than for much knowledge of their structures.

Note.—Prepared for the Biology Group of a Joint Conference on English and Science Work in High Schools, held at the University of Illinois February 16, 17, 18, 1905.

As a result, the teaching of those very important branches of the work, anatomy and morphology, becomes a delicate task, if it is to be accomplished without involving that unhappy result, the sickening of the pupil against the subject, and making him feel that botany is a useless study that lacks even the excuse of interest.

Students of college age find the use of the microscope trying, and cannot quickly become successful in its manipulation. Pupils in the first or second year of the high school, undertaking their first scientific work, come to it quite unaccustomed to the use of tools whose manipulation requires nice adjustment and with eyes untrained to accurate observation. If they are at once set to work with the microscope they can do nothing but flounder helplessly for a considerable time. They will eventually gain the power to use it successfully, but at what an expense of time and, in many cases, of interest. If, however, they are started with work which requires only such observation as may be accomplished by the naked eye and the use of simple tools, and if they are gradually lead to more and more manipulation of tools, and to the use of the hand lens and the dissecting microscope, there will come a time in the course of the work when they will be able to accustom themselves to the use of that most complex and delicate tool, the compound microscope, with at least comparative ease and little loss of time.

The objection is sometimes made that to begin otherwise renders it impossible to start the course with the lowest forms, and working upward to the Spermatophytes, to unfold in logical order the scheme of plant development. To teach the evolution of plants is not the sole object of high school botany; it may not be even the most important one, but if it were, it could be accomplished in the latter part of the course. A knowledge of the structure and life-processes and problems of the highest plants is by no means inimical to the attainment of a clear conception of the lower forms and the general relationships of the great groups of plants and the history of their development.

In the use of experimental apparatus a similar difficulty is to be avoided. Those experiments which the pupil himself conducts should at first be such as require the use of very simple apparatus, and the handling of only such materials as those with which he has had some previous acquaintance. Gradually he may

be introduced to more difficult work. For the most part, however, it is advisable that the more involved experiments, requiring the use of somewhat complex apparatus, be set up by the teacher, in the presence of the pupils. They can at that time be lead to a clear understanding of the reasons for all steps, and afterwards the pupils can make individual observations and draw their own conclusions. Many difficulties arising from size of classes, limited space and material, etc., are thus avoided, difficulties which would be very serious if one attempted to follow the ideal plan of having each pupil individually perform each experiment.

It is a difficult matter to say what can be done in physiological botany in the high school, so long as conditions differ as they do. Whether the course is one of a semester or of a year will naturally affect the amount accomplished, but in either case that amount will ultimately depend upon the enthusiasm and devotion of the teacher, upon the amount of time he is willing to spend in preparing apparatus and so arranging materials that the experiments may be set up before the pupils with the least possible drain upon class time.

Those divisions of physiological botany that are best adapted to high school work are those that are suggested by the work in anatomy. Either preceding or following each portion of work in anatomy should come related experiments in physiology which will explain the function of the structure studied.

As the pupil studies seeds and seedlings he can easily determine the nature of the food reserve with which each is provided and its value to the growing seedling. At the same time that he examines germinating seeds, a few experiments to show what conditions are requisite for germination will add not a little to his interest. Observing the persistence with which the roots of the seedlings reach downward and the plumule upward, he is led with willing mind through a series of experiments which culminate in convincing him of the influence of geotropism. Following naturally upon these experiments, come others demonstrating heliotropism and hydrotropism.

The study of the structure of root hairs inevitably raises the question as to how the soil water gets into the hair, and the demonstration of osmosis follows. In a year's course there would follow in natural sequence, experiments in plasmolysis. Root pressure may be easily demonstrated, even if a perfect explana-

tion is impossible. The demonstration of the acid excretion of roots will depend more upon the teacher's disposition to labor than upon any condition of the course.

Stem tissues are more interesting if their study has been preceded by some simple tests with red ink and iodine illustrating the rise of sap and the storage of food. Tissue tension is easy of demonstration by the pupil and is worth the little time it takes.

Experiments illustrating the value of and necessity for certain ingredients of the soil are impossible in the majority of schools, though the lessons they teach are important. However, it is quite within the range of possibility to prove the extreme importance of the power of a soil to retain moisture and to give it up gradually, so demonstrating the need for humus in the soil. This is a point which touches the lives of the pupils, and is therefore of decided interest to them; moreover, it leads easily to the subject of forestry, a topic which I believe ought to be touched upon in every course in botany. How else shall we obtain legislatures which will protect the forests the land still possesses, and reclaim denuded areas?

Parallel with the study of leaves must be performed a thorough course of experiments in photosynthesis, respiration and transpiration. The study of respiration should be conducted in connection with germinating seeds also, and in connection with it should be demonstrated the consequent evolution of heat.

All of these experiments will form the natural introduction to explanations of the anatomical studies, giving them meaning and increasing the pupil's interest in them.

In exactly the same manner, ecology should be made to illumine morphology. For instance, in the study of seeds and fruits one could scarcely avoid, if he would, the discussion of distribution of seeds and adaptations thereto. When leaves are the subject of study, their many modifications must be observed and the meaning of those modifications developed as far as possible. In the work with the anatomy of the flower, interest centers around its ecology, the problems of pollination.

In the portion of the course devoted to systematic botany, the ecology of every form can and should receive especial attention. The habitat of the form studied and the adaptations which fit it to that habitat alone make comprehensible the development of the vegetative structures of the various groups. Similarly, each

type of the flowering plants chosen for observation, whether they number six or ten, should be studied as a whole plant with other life-problems than merely that of pollination. Moreover, if they are carefully selected, they may not only represent families typical of the locality and illustrate different adaptations to securing pollination, but they may also include typical mesophytic forms, and forms which verge closely upon the hydrophytic with perhaps one which approaches the xerophytic. Thus, if the course be so brief that there is really no time for detailed study of plant societies, the leading ecological types will have been met with and some conception gained of the problems of plant life and the struggle for existence. In a semester's course, such work as has been outlined above would have to suffice, little more being done in out-of-door work than the calling of the pupil's attention when out on excursions to the fact that plants are grouped in societies and colonies.

The only thing that need condition the actual study of plant societies is the amount of time devoted to the work. For this field excursions are a necessity. The question of whether these excursions can be organized and how numerous they may be is again one that finds its answer in the earnestness and enthusiasm of the teacher and also in the amount of work imposed upon him. It is as necessary that the teacher of botany be able to persuade the school authorities of the necessity for so arranging the class hours that excursions may be made as natural a part of a botany course as is any other exercise connected with it, as it is that he impress upon them the need for physiological apparatus or for tables at which to work. Until this desirable state of affairs has been reached, he can have only voluntary excursions after school hours; these, however, will include the great majority of the class, and the teacher will be at a certain advantage in being relieved of any strain of discipline.

In the majority of towns the distances which must be traveled in order to find plants at home offer no insurmountable difficulties. Though a class spend half of its double period in getting to and from the place of observation, the time that is left will often be worth as much as twice that time spent in the indoor laboratory. In large cities the difficulty is usually greater, but even here there is generally a vacant lot within a reasonable distance. This difficulty of leaving the school in order to make field excursions

should in the near future be done away with in part, at least, by the establishment of the school botanical garden. Every earnest botany teacher should be doing what he can towards gaining for his school a portion of the school grounds or an adjacent plat which could be used for a botanical garden in which natural conditions of the flora of the region may be imitated. Such a garden may furnish much material for ecological work.

However, studies in it should never be allowed to supplant entirely the field excursion which takes the pupil abroad to the native haunts of the plants. A course in botany in which the field excursion has no place is not worthy of recognition. To study plants only in the narrow confines of a school laboratory, however well equipped it may be with apparatus, however well supplied with plants, and having studied it thus to think that one knows plants, is comparable to thinking one's self acquainted with man after having completed the prescribed courses of study in the anatomical and physiological laboratories and the hospitals of a medical college, though lacking any practical acquaintance with the world of men.

Field excursions must be organized and the pupil must go forth into the woods and fields, if there be no better place, into the vacant lot, there to witness with his own eyes the silent struggle for existence which is forever waging. Until he has seen a hillside whitened with the fragile stars of do-gtooth violet, or a dump-heap converted into a living mass of green by a luxurious growth of burdocks or wild mustard, what meaning will the phrase "plant colony" have for him? Whole chapters on plant societies carefully perused will do less for him than will two brief hours in a marsh, one in early spring when the violets are carpeting its borders with blue, and marsh marigolds are lighting its more watery spaces with stores of last year's hoarded sunshine, and another hour in the same spot when the violets have given way to fringed gentians and grass of Parnassus, to dainty Gerardias and great blue Lobelias; and Asters and bonesets, sunflowers and tall marsh thistles are abundant where the marigolds had spread their banks of gold.

A vacant city lot may furnish a place for study less ideal from an aesthetic standpoint than the marsh or woods, but it will be no whit less satisfactory from the purely scientific point of view. A level stretch of gravelly ground such as surrounds too many of

our city schools affords opportunity for the study of conditions approaching closely to the xerophytic. With carefully developed outlines of study in their hands such as would be furnished them for an anatomical study at the laboratory tables, a class of pupils can do as earnest and fruitful work in such a place as ever they could accomplish in their classroom.

Of course, before a field excursion is entered upon, the teacher should have planned it as carefully as he would any other recitation or laboratory period. The pupils should be provided with outlines similar to those they would use in the laboratory, prepared by the teacher after having carefully examined the ground to be studied and worked out the best setting of the problem which is to engage the pupil's attention. He must be able to see things himself and must have always the spirit of a student when he is in the field with the pupils.

Aside from the opportunities these trips afford for ecological work, they greatly increase the possibilities of teaching the native flora. In the reform for teaching nothing else than flora, we have gone too far, and many of us neglect that very important part of the work, forgetting that many pupils are led to take up the subject by a very legitimate desire to know the trees and herbs of their surroundings, and we deprive them of their rights if we limit ourselves to some six types of Angiosperms. Until nature study has reached a stage of perfection as yet only dreamed of, advanced botany should be left for colleges, and high school botany should be elementary.

Another benefit to be derived from the excursion, one which, in the writer's opinion, is no less important than those already named, is the increased interest in his surroundings, which the pupil should feel, and the deepened consciousness of the wonders and beauties of nature. This is a point which I know many scientists hesitate to mention. Allow me to quote in my support President Elliott of Harvard:

"We have become convinced that some intimate, sympathetic acquaintance with the natural objects of earth and sky adds greatly to the happiness of life, and that this acquaintance should be begun in childhood and be developed all through adolesence and maturity. A great need of modern industrial society is intellectual pleasures, or pleasures which, like music, combine delightful sensations with the gratifications of observation, association,

memory and sympathy. Society has seemed the natural setting for the cultivated person, man or woman; but the present conception of real culture contains not only a large development of this social element, but also an extension of interest and reverence to the animate creation and to those immense forces that set the earthly stage for man and all related beings. The idea of culture has always included a quick and wide sympathy with man; it should hereafter include sympathy with nature, and particularly with its living forms, a sympathy based on some accurate observation of nature."

There should be developed in the pupil by these excursions, an attitude of openness of mind, a habit of constant observation, which will make him all his life an observer of his surroundings, one who is ever asking new questions concerning the phenomena of nature, and who is ever endeavoring to find the answers to his questions.

In all the pupil's work, whether anatomical, physiological or ecological, the best results are to be obtained by placing each exercise before the pupil as a problem, giving in the outlines only such facts as one's knowledge of the class tells him the majority of the pupils will not readily discover for themselves.

As the teacher passes from individual to individual he can help the slower ones as much as may be necessary to prevent discouragement, and to lead them to the greatest gain. Thus the scientific method will be for the most part employed, and the pupils will make the greatest possible gain in habits of observation and in ability to attack a problem independently.

The work in experimental physiology is especially well adapted to the employment of the scientific method in its entirety. Take for example, the development of the subject of geotropism. The pupils observe in their first work in germination that all the hypocotyls have shown an amazing persistence in growing earthward, whatever obstacles they may have had to pass around, in whatever position the seeds may have lain. They see also that the plumule has shown an equally strong tendency to grow upward They infer that both members will always so conduct themselves, but to verify their inference they experiment by placing seeds to germinate in all possible positions, and by changing the position of young seedlings and watching the hypocotyls and plumules right themselves. Now the question arises, why do they so be-

have? There must be some influencing force; what is it? The pupils naturally suggest that the hypocotyl seeks earth and moisture, the plumule air and light.

The next problem is to verify or disprove their theory. With more or less assistance they hit upon various ways of testing the influence of light and of the various substances. Stems still grow erect in darkness, and seeds planted at the bottom of a can of moist earth hung high in the air will send their roots downward till they wither in the air and their stems pushing upward through the damp earth. Most of the pupils will realize that gravity is the only remaining force with which to reckon. The final experiment by which to demonstrate whether or not gravity is the controlling force must usually be suggested by the teacher. Seeds are allowed to germinate upon the revolving klinostat, and the question is settled. Gravity is the controlling force. Immediately arises another question—how does gravity act, as a pull? A little reasoning concerning the specific weights of earth and of delicate young roots answers this, but the well-known experiment in which the root grows downward through mercury is very impressive. The matter of irritability can now be developed to account for the root's response and to account for the force by which the root pushes through the heavy mercury. The pupil recalls his experiments with germinating seeds and the evolution of heat during respiration, and realizes that by the oxidation of its tissues the plant evolves the energy by which it performs its movements.

By such work the pupils may be trained into the scientific attitude toward unanswered questions, to habits of self-reliant investigation.

The habit of bringing together the results of his studies along any given line in the form of diagrams or charts or curves, is invaluable in testing the pupil's comprehension of the work supposedly accomplished. By means of such exercises he is enabled to recognize clearly essential points and to generalize; he is led to think to conclusions. Without them, his conception of the work is apt to be more or less vague and lacking in rounded completeness. The use of such devices may be overdone, but for a general summing up at the end of large topics, they are invaluable.

TROPICAL FRUITS.

By Mel T. Cook,

Director of the Division of Vegetable Pathology of the Cuban Agricultural Experimental Station.

I. BANANA.*

The tropical countries have a rather mysterious fascination for most of us. We usually think of them as lands of sunshine, birds, flowers and delicious fruits. Our ideas of the fruits are formed from our limited knowledge of the banana, orange and pineapple. As a matter of fact, the tropical fruits are no more delicious than fruits from northern countries, and the traveler must frequently acquire a taste for them before they can be enjoyed.

In this series of short articles on "Tropical Fruits" the banana will be considered first because it is one of those with which the readers of School Science and Mathematics are most famliar. Only a few years ago the banana was a luxury in many northern families. Although fairly common on the city markets, it was too expensive to be generally used by most families living in and near the small towns; but now so abundant and cheap as to be a common article of commerce in every corner grocery store, while in the cities it is frequently referred to as the poor man's fruit. There are probably more bananas shipped into the United States than all other tropical fruits combined. Despite the commonness of this fruit, few of us have more than a vague knowledge of its character and habits.

It belongs to the family *Musaceae,* and is a native of the eastern tropical countries, but has been introduced into practically all moist tropical countries. Most of the species are grown for fruits, a few for fiber, and a few as ornamental plants in subtropical countries or in greenhouses in cold countries. It thrives best in moist lowlands, and since most species and varieties seldom or never produce seeds it is necessary to propagate it from suckers which are being continually produced from just beneath the surface of the ground. In a well cultivated field three or four plants of different ages are allowed to stand in a cluster. The plant bears fruit in from twelve to eighteen months. Each plant fruits but once, and when the fruit is harvested the old stalk is destroyed, the young plants being allowed to remain. Thus a continuous crop can be produced without replanting, so long as the soil maintains its fertility, which is about four to six years.

* To be followed by other short articles.

Under the most favorable conditions the plants may reach twenty feet in height. The leaves are bright green, elliptical, pinnately-parallel veined, with sheathing petioles which form a false stem-like structure. The flowers are borne in a dense terminal raceme rising on a stalk through the false stem. They are unisexual and are borne in clusters (two rows in each cluster), and each cluster is covered by a large, dark-red bract. About one-fourth of the cluster at the base of the raceme contain only pistillate flowers while all others contain only staminate flowers. The bracts successively turn back, exposing the flower clusters. Each flower has a six-parted perianth, five parts united into one piece and known as the calyx, and one part single and known as the corolla. However, it is probable that two parts of this so-called calyx are really parts of the corolla. There are five stamens and a three-chambered inferior ovary. In the pistillate flowers the ovary is 3½ to 4 inches long, the other parts of the flower about 1¾ inches in length, and the stamens atrophied. In the staminate flowers the ovary is atrophied, being only about ¾ inch long, and the other parts about 2 inches in length, with well developed stamens.

When the plant is ready to bloom the bracts turn back successively, exposing the cluster of white flowers; the pistillate flowers being near the base of the raceme bloom first. As the successive clusters open the rachis continues to lengthen and the staminate flowers wither and fall, thus exposing a long rachis bearing on its tip the still active buds. The fruits bend at the point of their attachment with the rachis in such a manner that they point upwards.

The edible banana is *Musa sapientum* Linn, and can be grown in all moist tropical countries. A few are grown in Florida, Louisiana and other states on the gulf coast. There are a great many varieties of this species; the variety most commonly sold in the United States is the "Johnson," which is imported from Jamaica, Cuba and Central America. The fruit is not gathered when mature, but while yet green, and is partially ripened in shipping. Like all other tropical fruits, it ripens readily in dark, warm places.

Musa textilis is a native of the Philippines, where it is extensively grown for its fiber, which is sold on the market as Manila hemp. It is grown in dense groves and the plants are frequently twenty feet high. The fruit is not edible, but pro-

duces an abundance of seeds, which germinate readily. All the species produce good fibers, but none in such great abundance or of such quality as *M. textilis.* Many other species also produce fruits which are not only used as raw foods, but are also cooked and prepared into very palatable dishes. Banana flour has been made successfully, but as yet it is not a practicable product.

Fig. 1. Mature banana plant with suckers of various ages. The fruit with extension of the rachis from which the staminate flower have fallen A bract just turning back to expose cluster of young staminate flowers.

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

DEPARTMENT OF METROLOGY, NOTES.

Voluntary Use of the Metric System in England. Parliament in 1897 passed an act permitting the use of the metric system after two years. It will be a surprise to many to learn the extent of its adoption and use in less than seven years. At the hearings on weights and measures last year before the Select Committee of the House of Lords, H. J. Chaney, superintendent of the Standards Department of the Board of Trade, testified that the metric system "has been practically adopted in thirty-six of our largest cities and eleven counties in the United Kingdom, and standards of the metric system have been provided. With these standards the local inspectors of weights and measures have tested during the last five years about 20,000 weights and measures. Those weights and measures are voluntarily asked for as weights and measures for carrying out the testing of goods ordered in metric quantities." He also says that "metric standards are issued to all the districts throughout Canada for the use of the local inspector of weights and measures." "I think that the practice of local authorities of obtaining local standards on the metric system is a growing one."

Charles A. de Pury, chief accountant of the Brighton railway, testified: "So as a matter of fact we have for the foreign traffic the metric system as regards measures, and we have the decimal system as regards money." Also: "We have rates with the continent on a so-called ton of 2,205 pounds, 1,000 kilos." "The system has been in force for a number of years."

The Association of Chambers of Commerce of the United Kingdom, on February 28, 1905, passed without a dissenting vote the folowing resolution:

"That this association urges upon the government the importance of further legislation to secure the more general adoption of the metric system of weights and measures, especially in connection with the export trade to countries where that system is in compulsory use." R. P. W.

BOTANICAL NOTES.

In the April number of *Arboriculture* appears an important article on "The Mathematics of Forestry." The article is made up of material presented in a paper before the meeting of the Forest Congress in Washington by the engineer of maintenance of way of the Pennsylvania Railway east of Pittsburg. It is estimated that there are now in use 620,000,000 crossties in the United States, and that repairs and extensions annually require about 100,000,000 new ones. This requires annually the timber

from 200,000 acres of woodland. The Pennsylvania railway system, which uses nearly 4,000,000 ties annually, is trying to make partial preparation for future needs by extensive plantings of the yellow locust, the number planted to date being 280,530. It would require 97,500 acres of timber land being constantly replanted as trees were removed to supply this one system for its lines east of Pittsburg. It would require 500 acres of forest to supply the 2,444,800 fence posts used by the Louisville & Nashville railway. The reviewer of the original paper is of the opinion that *Catalpa speciosa* would supply the needs of railways in a better way, and would use less acreage in doing so than those species of trees now used. He estimates that 600 square miles of territory in eighteen years for the first crop and fifteen years more for the second crop would produce crossties sufficient to renew the 620,000,000 now used by all the railways of the United States.

"The Sea Weed Industries of Japan," by Hugh M. Smith, recently appeared as a separate publication of the U. S. Bureau of Fisheries. It is full of interesting and useful information. Numerous pictures add much to the clearness of the description. In an appendix on "Utilization of Seaweeds in the United States," among other statements is the following regarding Irish moss (*Chrondrus crispus*): "One hundred and thirty-six men were employed in gathering this plant in 1902; the boats, rakes and shore property used were valued at over $12,000, and the quantity of dried algae sold was 740,000 pounds, with a market value of $33,300. In 1898 the output was 770,000 pounds, valued at $24,825."

The March number of the *American Botanist* contains the following suggestive titles: "The Colors of Northern Flowers;" "The Earliest Spring Blossoms;" "Stirrings of Life;" "A Sphagnum Bog," and "Luminous Plants."

EARTH SCIENCE NOTES.

Spectographic determinations of the period of rotation of Venus and of Mars made by Mr. Percival Lowell at the Flagstaff observatory in Arizona indicate the period for Venus to be 225 days and for Mars 24 hours and 37 minutes.

A study of the dust of the atmosphere at Paris shows that from 2 to 9 milligrams fall per square meter in a day. About a third of it is organic. The inorganic constituents are iron, its oxides, and other meteoric materials, ammonium nitrate and sodium sulphate (easily crystallizing in the soil or formed in the air from sulphuric acid, other sulphates, and soda or common salt); sodium chloride itself is rare; barote, phosphate and salts of calcium, magnesia and aluminum are still rarer.

It has been calculated that 2×10^{-7} grams of radium per cubic meter uniformly distributed through the mass of the earth would suffice to maintain its temperature. The radio-activity of the soil requires about 1,000 times this amount. It has therefore been suggested that the radium is more concentrated near the surface, and in that case the increase in temperature which is observed in borings might be confined to surface layers.

The Tennessee river flows southward for some distance in the eastern part of Tennessee in a broad longitudinal valley. Near the city of Chattanooga it turns abruptly westward through a deep, narrow, winding gorge, which is cut in the high, flat-topped mountain known as Walden Ridge. Two hypotheses have been advanced in explanation of this peculiar course. The favored hypothesis in recent years has been that it is due to piracy; that throughout the tertiary cycle of erosion the river followed the longitudinal valley east of the mountain and flowed into the Gulf of Mexico by way of the Coasa and Alabama rivers, but that at the close of the Tertiary cycle the river was tapped at a point near Chattanooga by a branch of a stream occupying a valley west of the mountain and so diverted from the former southerly course below Chattanooga to its present westerly course through the gorge in Walden Ridge. The other hypothesis is the one which is favored by Mr. Douglas W. Johnson in a discussion of the subject in the April-May number of the *Journal of Geology.* According to this hypothesis the Tennessee acquired its present course across the mountain some time before the close of the cretaceous period of baseleveling when the present top of the mountain was continuous with the rest of the cretaceous peneplain, and has maintained its course, cutting out the narrow transverse gorge through Walden Ridge at the same time that the broad longitudinal valleys in the softer rock were being cut.

In recent years it has been recognized that there was more than one center from which the ice spread during the glacial period. One of these centers—the Kewatin—was situated west of Hudson Bay, and east of Hudson Bay was the Labradorean center. An article on the "Glacial Features of the St. Croix Dalles Region," by Mr. R. T. Chamberlin, in the April-May number of the *Journal of Geology,* brings out the relation in that region between the ice coming from the Kewatin center and the Labradorean center in the late Wisconsin stage of the ice invasion. The ice coming from the Labradorean snow fields made its advance through the Duluth finger of the Lake Superior basin and reached the region of the St. Croix Dalles by a southeasterly movement in the left flank of the ice lobe. It brought drift which has a conspicuous red color, a sandy matrix and no limestone. The ice spreading from the Kewatin center down the Red River valley advanced from the west into the St. Croix region after the ice depositing the red drift from the Lake Superior basin had retreated. The Kewatin glacier overrode the red drift and left over it a mantle of grey drift characterized by a clayey matrix and the presence of limestone.

Report of Meetings.

REPORT OF MEETINGS OF THE MICHIGAN ACADEMY OF SCIENCE.

The 1905 academy meeting was held in Ann Arbor in conjunction with the Michigan School Masters' Club. It was very largely attended and was full of good things for teachers and practical people. Two addresses made it of unusual interest, one was by Prof. T. C. Chamberlain, of Chicago,

who presented his theory of the origin of the earth, the planetissimal hypothesis. It was illustrated with lantern slides of nebulæ.

The other paper was by the president of the academy, A. C. Lane, state geologist of Michigan, and dealt with "Our Natural Resources, Their Consumption and Conservation."

Since the problem of the rural school is coming into more prominence the report of the meetings of the section of agriculture is here given. This was furnished by W. I. Beal, of the Agricultural College.

For a few years past the academy has maintained a section of agriculture, the only section of its kind in this country, so far as we know.

This year the subjects for papers all fell under the general heading "Agricultural Education," ranging from low grades to college. The attempt was made to make the sessions intensely practical, that teachers and others present might pick out some valuable points which would be of use.

President K. L. Butterfield, of Rhode Island, sent us a syllabus for a course in rural sociology, one in farm economics, one in farm economy. They were much admired. Professor R. S. Shaw exhibited large cards containing a syllabus for a four-year course in live stock husbandry, beginning with high school graduates. The plan was excellent and showed much thought. The course included other topics than the study of live stock. In the training of students he spoke of the importance of their feeding the animals, and of taking part in the examination of the meat as it was cut up. He called attention to the fact that many times the best judges, before killing, were unable to select the best steer or sheep for the block.

Dr. Beal made some comments on a two-year course in agriculture, a syllabus of which hung on the wall. The chart was a copy of the course for boys, as adopted in the county agricultural schools of Wisconsin, now well maintained and popular.

Professor Jeffery, of the Agricultural College, enumerated and explained a large number of lessons that can be introduced with profit in county schools; these all pertained to the study of soils. Such hints and illustrations were very instructive to those who were interested in such work.

Hon. C. W. Garfield's paper teemed with happy remarks concerning the efforts of a certain young man who taught a country school. With his efforts a museum was collected, classified and installed in the school house, much to the gratification and instruction of the pupils. The collection was a fine investment, even for a single term, although it was expected that the most of the specimens would soon be destroyed.

Professor Dandeno, of the Agricultural College, graphically related his experience in the management of a school garden while a teacher in a country school in Canada. The difficulties were too numerous to be surmounted by any excepting well-trained teachers fitted for the work, and then great perseverance and tact were required.

For a full hour, Prof. L. H. Bailey, of Cornell University, instructed and entertained those present in his admirable account of his recent efforts

in planning courses of study for the lower grades of schools in New York state, the course pertaining to agriculture and nature study.

The first meeting of the zoölogical section had a varied program.

Dr. Duerden, of Ann Arbor, gave some notes on his natural history observations in Hawaii. He showed many especially fine lantern slides of corals.

Mr. Mast, of Hope College, presented good evidence which showed that Stentor does not react to the stimulus of light according to the Loeb theory of tropism.

Mr. Clawson maintained in his paper that in the case of the crawfish the morphologically homologous organs are no more highly or closely correlated on the whole than the non-homologous.

Several papers dealt with data for the study of variation. Dr. Pearl and Miss Dunbar gave the results of the measurements of some 7,000 paramoecia, which were derived from a single one which had been isolated, carefully measured and allowed to reproduce a normal culture. Two different artificial cultures were used for later generations which gave rise to variations in size.

The second meeting was largely devoted to a report of the natural history expedition to Northern Michigan, made during the summer of 1904, under the direction of Chas. C. Adams, curator of the museum of the University of Michigan.

The expedition was made possible through the generosity of certain public spirited friends of the university. The funds of the museum are too limited to carry on this very important line of work, without special aid. The major part of the funds were the combined gifts of Mr. Bryant Walker, of Detroit, Hon. Peter White and Mr. N. M. Kaufman, of Marquette. The Board of Regents of the University generously contributed the expense of transportation, not otherwise provided.

The field party was in charge of N. A. Wood, the museum taxidermist. He was assisted by A. G. Ruthven, who had charge of the scientific work, and who directed it along lines outlined by the leader, Curator Adams. About one month was spent in exploring the Porcupine mountains. Camp was made at an abandoned mine. The field work was carried on through a detailed study of selected localities. After a preliminary examination of the region, Mr. Ruthven selected a series of representative habitats beginning at the lake and extending southward across the mountains. The various members of the party then visited these stations, where they made observations and collections. In this way not only were specimens collected, but the conditions under which they were found was thus definitely recorded. Nearly three weeks were spent making a hasty survey of the lower end of Isle Royale, about 60 miles northwest of Houghton. A detailed report on the observations and collections is now in process of preparation, so that at this time it will only be necessary to call attention to some of the general results. No effort was made to make a complete collection of the animal and plant life in general, but special attention was given to the trees and shrubs, molluscs, fish, amphibians, reptiles, birds and

mammals. This is apparently a long list, but it must be remembered that so far to the north the variety of fish, reptiles and amphibians is quite limited, so that attention was mainly devoted to the trees and shrubs, molluscs, birds and mammals. About 90 species of birds were observed in the Porcupines, and about 80 at Isle Royale. Of the birds recorded several are new breeding records for Michigan and two appear to be for the United States.

More detailed and ecological work is hoped to be accomplished by the survey another season.

(The above is quoted from an article which appeared in the Bulletin of the Michigan Ornithological Club, for December, 1904.)

In the geology and geography section of which Prof. Jefferson, of Ypsilanti, was vice-president, one of the most interesting papers was by Mr. Moseley, of Sandusky, on the change of level of Lake Erie.

Mr. Moseley said in part:—Tilting of the land is depressing the west portion of Lake Erie relative to the outlet at Niagara, thus causing the water to rise and overflow the banks. This can be proved in many ways:

First. By submerged river valleys. The streams which entered the lake when it was at a lower level cut deeper valleys than they can at present. These can be traced out into the lake for several miles by the slack current and by borings which reveal soft mud easily distinguished from the glacial clay. One such valley extends below and beyond a sand spit which has been previously formed across it.

Second. By submerged structures in vicinity of Sandusky. Roads, fields, forests and Indian graves have been found below the present water level. Submerged stalactites and stalagmites can be seen in several of the caves on Put-in-Bay Island.

Third. By the plants. The flora of the Put-in-Bay group of islands indicates that it formed part of the mainland in post glacial times.

Fourth. By action of historic storms. Parallel ridges of sand and gravel have been thrown up by northeast gales occurring at times when the lake was above normal level. The approximate age of these is shown by the vegetation which they support. The deposits of wave-washed debris shows that the height to which the water dashed is greater in the more recent ridges. By dividing the difference in level in any two of the ridges with the difference in time of formation, the rate at which the lake has risen is estimate to be about 2.14 feet per century.

Detailed account of these ridges can be had in an article published by the Ohio State Academy: "Formation of Sandusky Bay and Cedar Point."

Another subject of the geology and geography programs which was much enjoyed was that of a glacier in British Columbia by Prof. W. H. Sherzer, of Ypsilanti. A general description beautifully illustrated with lantern slides, was given of the Wenkchemna glacier in the valley of the Ten Peaks, lying just to the north of the Great Divide, in the Canadian Rockies. (We quote directly from him.) "This glacier is of especial geological interest in that it is of the 'piedmont type,' and small enough to be gotten into a single slide. The glacier has about one dozen component

streams, some of which are stationary, some retreating very slowly and others advancing and cutting the trees of the adjoining forest. The glacier is of the broad-short type, similiar to its prototype, the Malaspina, of Alaska, having a breadth of about three miles and a length of one-half to one mile. It lies between 6,000 and 8,000 feet above the sea level, has a relatively small nevé field and has persisted only because of its relation to the Wenkchemna group of peaks, which have protected it from the sun's rays and contributed rock material with which the surface and front are almost completely veneered. The body of ice is a very sluggish one and the drainage stream is carrying no sediment. Less than a mile from the glacier this stream enters Moraine Lake, of a gorgeous blue color, because of the lack of sediment. The entire absence of a delta shows that the glacier has been geologically inactive for centuries. This lake owes its origin to an ancient moraine formed by the easternmost tributary of the glacier when it was much more extended than at present." This glacier is described in the forthcoming volume of the Smithsonian Institution, at Washington.

The section on science teaching proved very popular. Over 200 people listened attentively to the symposium on field work which Vice-President Sherzer had arranged.

The first paper was given by Mr. I. B. Meyers of the School of Education, University of Chicago. It was a most carefully thought-out treatise on the Aims and Methods of Elementary Field Work. From the praise which it has received we believe that it was effective as well as able. The speaker evidently believes so thoroughly in the necessity of the contact of the child and nature for a basis of sound education that he made very plain how simple, natural and right a matter it is for the school to take advantage of the native impulse for original research work on the part of the child; and further how mere curiosity and love of adventure can be transformed into civic and social virtues by placing the pupil where he must learn his own lessons, bear the results of his own observations, conclusions and acts.

Not many formal lessons were advocated, but rather the giving of experiences which should make the children as fully aware as possible of their complete environment.

Observation of the weather and home geography were to form the basis of the plant and animal work; and the combination of these, weather, topography, plants and animals, their relation and inter-dependence, was ultimately to be realized. However, the first work would naturally be the mere collecting of data and specimens and learning how to keep records, pictorial and written, and how to arrange the material for permanent school and home museums.

The paper was amply illustrated by drawings and charts of actual school work done by the children of the elementary grades in the School of Education, Chicago. A series of water colors depicting a simple landscape was used to show the progression of the seasons, the whole forming a pictorial calendar; oblongs of cardboard showing the size of the shadow cast by the shadow stick on successive weeks during a season gave a very graphic representation of the varying intensity of the sun's energy during that time

and place. The water color sketches of the dandelion at various stages of development were suggestive of the changes from winter to summer conditions.

We counted ourselves fortunate in having with us Prof. L. H. Bailey, of Cornell, who in discussing Mr. Meyer's paper criticised adversely but one point. He would have each field trip more rigidly planned and the object made definitely known, in order to avoid confusion.

He urged familiarity and contentment, on the part of the teachers, with their physical environment and the weather, which latter he said was *always* "good." He advocated a study of the artificial as well as natural environments—creameries, bakeries, and the electric light plants, etc. He then gave us an outline of field work along three different lines for children:—Weather, scenery, and plant and animal inhabitants. The work of the school garden was emphasized.

Following in natural sequence was a paper by Professor Jefferson, of Michigan State Normal College, at Ypsilanti, on "Field Work in Geography." He spoke briefly, but to the point. He reminded us that here as in all other subjects by whatever method the *aim* of field work was to understand the thing studied. "We don't enjoy a picture or song or dinner by reading about it, but by seeing it, hearing it, or eating it. If out of reach we may take some pleasure in the description, but not with any thought that we are having something as good as the thing itself. Why *not* study the forms of geography directly?"

Prof. R. D. Calkins, of the State Normal, at Mt. Pleasant, Mich., followed with the suggestion that a little gumption on the part of superintendents and principals would solve the difficulty of "lack of time," an objection too often raised to field work. He did not agree that field work should always precede class work, but that past experience of the pupil might in many cases be relied upon.

Next in order was a paper on "Field Work in Botany," by Dr. H. C. Cowles, of Chicago, which was opened by one of his striking and original statements:—"At school the love of nature is *choked out* of the children because so many other things are *choked down*. At home it is *clubbed out* because it brings *mud in*."

One of his strongest points was that the best type of field work is that which combines the study of adaptation with the study of structure and function. Of this he gave several illustrations. Among the difficulties of doing good field work he said that first and last, is the difficulty of getting a good teacher, and declared that the successful teacher, of natural science especially, must be so infected with the teaching microbe as to be rendered "incurable."

Mr. Moseley, of Sandusky High School, added, in the discussion of Dr. Cowles' paper, some practical illustrations of how the field work is carried on in his high school classes.

Although most expeditiously managed the program proved too long for the one session, and unfortunately the meeting had to be closed without the papers on "Field Work in Zoology," by Curator Adams, of the Uni-

versity of Michigan Museum, and "Field Work for Winter," by Mr. Bretz, of Albion College; and no general discussion could be indulged in as we all had hoped. As the papers will all appear in full in the annual report of the academy, those interested can secure them by writing the secretary, Professor Marshall, of the Agricultural College. JESSE PHELPS.

INDIANA STATE SCIENCE TEACHERS' ASSOCIATION.

The annual meeting of the Indiana Science Teacher's Association was held in Indianapolis April 28 and 29. The first session was held in the chemical lecture room of Shortridge high school. The first paper was given by Mr. W. A. Fiske, of Richmond. He spoke in favor of the affiliation of the Science Association with the Central Association of Science and Mathematics Teachers. The idea of an alliance was discussed by Mr. Charles H. Smith, Editor of SCHOOL SCIENCE AND MATHEMATICS, and Principal George W. Benton. The discussion led to the appointment of a committee, consisting of Mr. Fiske, Mr. Benton and Mr. Naylor, to consider such an alliance, and, if this step were desirable, to amend the constitution of the association in such ways as may be necessary. The committee subsequently reported favorably. The amended constitution was unanimously adopted, thus affiliating the two associations. SCHOOL SCIENCE AND MATHEMATICS was made the official organ of the association.

Mr. L. B. McMullen, of Shortridge, gave a report on the science teaching in the State. A committee on resolutions consisting of Messrs. Williams, Ratliff, and Torrence, and a committee on nominations consisting of Messrs. Baker, Breeze, and Stahl, were appointed by President Bush. The second session was held at Manual Training high school. Addresses were made by Superintendent W. A. Wirt, of Bluffton; Dr. Naylor, of De Pauw University, and G. C. Bush, the retiring president. Mr. Wirt spoke on the "Desirability of a Change in the Organization of High Schools." Dr. Naylor's talk upon "The School Shop" was exceedingly practical and interesting. Mr. Bush discussed "The Status of the Physical Sciences in the High School."

The afternoon meeting was held in Shortridge high school. An innovation in the form of sectional meetings was introduced. The general session was divided into biology, chemistry, and physics sections. The biology section was addressed by Prof. E. G. Martin, of Purdue; Prof. M. B. Thomas, of Wabash College; Mr. Scott, of Terre Haute; Mr. Douglass, of Anderson, and Mr. Ramsey, of Ft. Wayne. Prof. William M. Blanchard, of DePauw; Mr. Rector, of Muncie; Mr. Breeze, of Delphi; Mr. Clarke, of Indianapolis, and Mr. Wade, of Indianapolis, spoke before the chemistry section.

Mr. Underwood, of Indianapolis; Miss Van Dyke, of Newcastle; Mr. Life, of Marion; Mr. Haseman, of Elwood; Mr. Smith, of Union City; Mr. Ratliff, of Danville; Mr. Torrence, of Richmond, and Mr. Steele, of Greencastle, prepared work for the physics section. The sectional plan seemed to meet with quite general satisfaction.

The following officers were named for the ensuing year: President, L. B. McMullen, of Indianapolis; vice-president, Earl E. Ramsey, of Ft. Wayne; secretary-treasurer, W. I. Thompson, of Richmond; executive committee, Leonard Young, of Evansville, and Cyrus Rector, of Muncie.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

The twenty-second meeting was held in Boston, February 18, 1905. The morning session was devoted to a report of the committee on new apparatus, the address of the retiring president, Lyman G. Smith, and a conference on the topic, "What Should Constitute a Second Year's Course in Chemistry in the High School" In the afternoon the members listened to an illustrated lecture by Dr. William H. Walker, of the Massachusetts Institute of Technology, on "The Fixation of Atmospheric Nitrogen."

Mr. George A. Cowen, chairman of the committee on new apparatus, called attention to a new form of balance, sensitive to one milligram, and obtainable at the Knott Apparatus Company, and to a set of weights, offered by Bausch & Lomb, the latter being very desirable because provided with a cover enabling the box to be tumbled over without the upsetting of the weights. The same firm (B. & L.) places on the market a neatly graduated thermometer in a stout wooden case, special emphasis being laid upon the protection afforded by the case. Mr. Cowen then exhibited a simple arrangement for collecting gases over water. A little opening is made in the rim of a flower-pot saucer by making two saw cuts and breaking out the piece between. A hole is then bored in the middle of the saucer. The inverted saucer is placed in a shallow tin pan, and a rubber tube is passed from the generator through the opening in the rim and up through the hole in the middle of the saucer. If desired, a hole may be bored in the side of the tin pan, into which a rubber drainage tube may be tightly inserted in order to keep the water at a constant level in the pan. The report concluded with a few explanatory remarks, aided by diagrams, illustrative of a cheap, home-made reflectoscope which Mr. Cowen has used with excellent results in his classes at the West Roxbury high school.

Mr. Lyman G. Smith, the retiring president, spoke in part as follows:

"Some recent experiments with pupils in high school graduating classes have shown great deficiencies in the most common arithmetical processes. Complaints, not only from colleges and technical schools, but also from business men, that boys and girls cannot perform even simple calculations in mental arithmetic, have become too frequent. The same is true in regard to absurd blunders in simple English. The tests referred to, carried on by independent observers, have frequently shown that the simplest requirements cannot be met by half the high school graduates, if the questions are put to them as they come in real life, off hand. It would be unjust to lay this to the teachers in grammar schools. They have, with great labor, prepared these very pupils to pull through examinations in bank discount, mensuration, cube root, and other complications. It is not the fault of the teachers, but of the general system of instruction."

"The remedy for these defects may be found in more carefully chosen topics and nothing short of a high degree of attainment. Is it not unwise to consider qualitative analysis for pupils who have very vague ideas of the elementary principles of chemistry, and whose acquaintance with the range and nature of the substances to be identified is yet very limited? This is a time-worn idea, but it is always true, whether applied to general education, or to our own subject of chemistry. Teachers are very generally, almost universally, conscientious, eager, and enthusiastic, and should be given a chance. They deserve a generous portion of time for rest and study and general self-improvement. It is unwise to send them around the country after an exhausting day of teaching, to settle the athletic broils of irresponsible youngsters who ought to be at home under their parents' direction, or else getting real physical education, in a gynasium under a competent teacher of the subject. The teacher's responsibility is large enough already. Don't increase it. Leave a little for the parents. Don't let fathers and mothers get bewildered by queer school policy, and they will recognize teachers as masters of their profession instead of looking upon them as weak and uncertain elements."

The principal address in the conference upon second year chemistry was by Professor Charlotte Roberts, of Wellesley College, who favors general chemistry rather than qualitative analysis, and gave the folowing reasons for her position:

"1. It seems to me that too much stress cannot be laid upon a thorough grounding in the fundamentals of the science. Much of the work done in general Chemistry must be constantly referred to in all the later courses in the subject, and therefore the foundations must be thoroughly laid if success is to follow the student. Even though such a course might involve some repetition of the work done in the preceding year, that would not seem to me altogether a disadvantage. The facts of Chemistry to be memorized are numerous, and repetition seems to be the only way to impress them permanently upon the mind.

"Because I think, then, that the most thorough grounding possible in the fundamentals of the science is essential for the student who wishes to go on with the subject later, and because I believe also that general chemistry is best adapted to furnish the general and useful information required by students who *do not* expect to continue the subject, I advocate the study of general Chemistry rather than Qualitative analysis in the second year of work in the secondary school."

"2. General Chemistry is a science, and systematic qualitative analysis is an art. The former seems to me, therefore, better fitted to furnish the mental development which it is the function of the secondary school to give. While admitting that qualitative analysis may be taught in such a way as to furnish the most valuable mental development, it seems to me that, when taught in that way, the student is getting—under the name of qualitative analysis—much which might equally well have been acquired in general chemistry under the study of the metals. The tests for the most important metals, their separation from one another, and the principles

upon which their division into classes depends, I would have taken up under general chemistry, but leave the more technical processes of systematic qualitative analysis until later."

"3. My third reason for advocating a study of general chemistry rather than qualitative analysis is, that the student who enters from a secondary school on two years' work in chemistry may and should be adequately fitted to go into second-year work along with the student who has had his first year's work in college, and I believe that this is usually possible only when the student has had two years of thorough work in general chemistry in the secondary school. With such a course he may have a *better* knowledge of the subject than his friend who has begun the study in college, but that is no disadvantage to him, whereas it is a constant drawback to him to be found lacking in the elementary work."

"My verdict, then, as to what would constitute a suitable course in chemistry for secondary schools would be:

"For the first year—general chemistry. For the second year—general chemistry."

Miss Laura B. White, of the Boston Girl's High School, favored qualitative analysis as the second year subject and spoke in part as follows:

"I take qualitative analysis, then, because, after the first-year course, the student is ready for a branch of chemistry that gives him an individual mastery of his knowledge, with quick verdicts as to the correctness of his work—it is easy to show from his notes when he went wrong and why;—and because I believe that at this time qualitative analysis gives to the student greater values, intellectual and ethical, than anything I know in the whole curriculum of studies.

"It trains his logical reasoning powers, shows him the beauty of law and order, makes him careful in his judging, and gives him truthfulness or the power to see the truth although every fibre in his being makes him wish to have it otherwise.

"Aside from all this, a knowledge of qualitative analysis is of great use in many other branches of chemical investigation; it is almost indispensable to thorough advanced work in botany, physiology and kindred sciences, and is useful in the every day problems of the home.

"The usefulness of this course depends on a thorough first-year course—a year packed with foundation truths of chemistry organized into a vital epitome of the wholeness of chemistry."

The subject was discussed by other members of the association. After lunch at the Technology Club, the association was addressed by Dr. William H. Walker on "The Fixation of Atmospheric Nitrogen:"

"A number of years ago the English economist, Malthus, by a series of elaborate calculations, arrived at the conclusion that if the human race continued to increase as it was then doing, a food famine must inevitably ensue. No less an authority than Sir William Crookes predicted that if the exhaustion of the soil of England progressed in the ratio that then obtained, this country would experience a wheat famine within forty or fifty years. It is well known that growing plants remove from the soil

potassium, phosphorus, and nitrogen; their carbon content is furnished from the atmosphere. Some idea of the enormous value of the first three constituents thus withdrawn may be obtained from a calculation made some years ago by Dr. Wiley, of the Department of Agriculture. After giving a conservative value for each of the three constituents, he found that in the United States alone, agricultural crops removed from the soil each year, potash, phosphoric acid, and nitrogen to the value of $3,200,000,000.00. Of this enormous sum, three-fourths is from nitrogen. To be sure, this value is not entirely lost, for a goodly portion is returned to the soil in the form of refuse and barnyard manure; but when we consider the enormous quantities of straw which are burned in the West and the terrible waste incident to our modern method of sewage disposal, the annual loss to the country becomes apparent.

"The first attempt to replenish the nitrogen of the soil was through the importation of guano; the supply of this material has already failed. Our present sources are the animal waste from slaughter houses, the ammonia recovered in the destructive distillation of coal, and Chili saltpeter. Comparatively speaking, the first two are small. At the present rate of consumption, it is estimated that the South American nitrate beds will be exhausted in from forty to fifty years. Deposits of nitrate salts have been located in Egypt and in the southwestern deserts of the United States; but of their size and value, little is as yet known.

"It seems a peculiar provision in nature, that plants should obtain their entire supply of carbon from the atmosphere, which at most contains but a fraction of a per cent of carbon dioxide, while they are unable to utilize the unlimited supply of nitrogen ever present around them. To convert this inexpensive and inexhaustible supply of nitrogen into forms that can be utilized by growing plants and other industrial establishments, forms one of the most important problems in the technical chemistry of the present. It is interesting to note that almost one hundred years ago, this field proved industrially attractive. Nitrogen had long been considered the most inert of our common elements, and that it could be made to react on an industrial scale with other ordinary compounds was not considered possible. In 1813 Zinken observed a mass of salt exuding from a crack in the bosh of a blast furnace in lower Germany which upon examination proved to be potassium cyanide. As the furnace was fed with charcoal, the potash and carbon could easily be accounted for. The nitrogen could come only from the atmosphere. This was the start for a long series of investigations and experiments which led finally to the erection by two Frenchmen of a plant for the manufacture of potassium ferrocyanide, which depended for its supply of nitrogen upon the atmosphere. Charcoal saturated with potash was heated to incandescence in fire-clay retorts, while air, from which the oxygen had been removed was forced through the mass. The product of this reaction was then mixed with an iron salt, producing the desired compound. This plant was subsequently moved to Newcastle-on-Tyne, where it was enlarged to the production of one ton per day. Owing to the enormous waste of fuel incident to driving the heat through the thick

retorts, to the loss of potash from volatilization, and to the expense of the retorts themselves, which rapidly deteriorated in the presence of potash, the process was abandoned. Berthelot later studied this reaction and determined that what he called potassium acetylide (K_2C_2) was first formed, and that this later combined with nitrogen, forming potassium cyanide.

"With the advent of cheap electricity and the discovery of the formation of the carbides of the alkaline earth metals, this problem was again attacked. It was found that when calcium or barium carbide was acted upon by nitrogen at a moderate temperature, a certain amount of cyanide was formed. The Siemens & Halske Co. of Germany and the Ampère Chemical Co. of the United States each achieved considerable success along this line. It developed, however, that the reaction did not proceed as quantatively as had been expected. Instead of the simple union $BaC_2 + N_2 = Ba(CN)_2$, a considerable portion of reacting carbide formed barium cyanamide ($BaCN_2$) with the separation of free carbon. When calcium is employed, this by-reaction plays an even more important part. While barium cyanide by treatment with potassium carbonate may be converted into potassium cyanide and insoluble barium carbonate with considerable ease, barium cyanamide does not react so quantitatively. The chemical engineering difficulties inherent in the separation and purification of the finished product have been so great that commercial success for the process can scarcely yet be claimed. The American firm has, for the present at least, suspended operation. The German people are placing calcium cyanamide on the market in small quantities under the name of 'Kalkstickstoff.' This compound, in contra-distinction to the cyanides, is an efficient plant food and can be used directly as the nitrogen furnishing element of synthetic fertilizers.

"Although there is yet much to be done before these processes are important factors in the supply of nitrogen compounds, it is our belief that the field is a very promising one.

"It has long been known that a high potential electric discharge effects the combination of nitrogen and oxygen. Thus, lightning has been claimed to be a valuable economical agent when considered from this point of view. The cheap production of electricity has in this case also been a stimulus to endeavor towards the industrial utilization of this reaction. A number of concerns abroad and numerous investigators at home, among the more prominent of whom is the Atmospheric Products Co. of Niagara Falls, have made considerable progress in this direction. A small current at high voltage is caused to form a large number of spark gaps over which air is passed. The efficiency of the reaction is so limited by the dissociation of the oxides of nitrogen already formed, that up to the present no economical results have been obtained. We believe that, if a thorough knowledge of Chemical engineering were combined with the knowledge of electrical engineering already in evidence, this process also would have a great industrial future.

"From energy furnished in the form of lightning we now pass to energy as utilized by the unassuming, yet in countless numbers ever present, bac-

teria. As long ago as the time of Pliny, it was known that certain pod-bearing crops—the *leguminosae*—had a decidedly beneficial effect upon the soil. Pliny wrote: 'The lupine enriches the field or the vineyard as well as the very best manure.' Various theories were advanced to account for this fertilizing effect and as late as 1887 Storer in his classic work on agriculture points out that clover and beans and other leguminous crops seem to be able to derive nitrogen from the deeper parts of the soil; having long tap roots they are able to transport nitrogen compounds from the lower depths to the surface. He pointed out that, if judiciously used, clover seed was the cheapest manure the farmer could buy.

"It was noted that there always existed at the roots of the plants having this beneficial effect small warts or nodules. These at first were considered evidences of disease. It remained for a German to prove that they were caused by and largely made of micro-organisms. In a cross section of such a nodule the cell wall may be observed completely filled in with a species of very small bacteria. It was not long before it was conclusively proven that to these bacteria must be ascribed the fertilizing effect of the crop. The beneficial operation was found to be nothing more or less than the fixation of atmospheric nitrogen. Artificial inoculation of the soil on which had never been grown a leguminous crop, by soil from a field where legumes grew luxuriantly had already been practiced. It was but an easy step, therefore, to the preparation of a culture of the bacteria found in the nodules and with it the inoculation of seeds and soils. Professor Nobbe of Tharandt prepared a culture, using as a nutrient medium solutions containing large quantities of albumen. To this he gave the trade name of 'Nitragin' and distributed it throughout the country. At first fair success followed this introduction, but soon the failures became so numerous that the enterprise was discontinued. At this point the inventive genius of an American, Dr. George T. Moore, came to the rescue. He concluded that Nobbe had not cultivated his nitrogen-fixing bacteria in a way which would increase their natural tendency to assimilate this form of food. The German method gave the bacteria the nitrogen they wanted in the culture medium and as they had no work to do they rapidly deteriorated, losing their ability, from a nitrogen point of view, to shift for themselves. Dr. Moore took the opposite method and grew the bacteria upon silicic acid plates practically free from nitrogen, thus developing their original tendency to obtain their nitrogen supply from the atmosphere. This proved to be the secret which Nobbe had overlooked. A further contribution was made in the discovery that when dried down upon cotton, cultures of these bacteria did not lose their vitality, but quickly resumed their normal conditions, when again placed in water. In order to guarantee the privilege of the use of this important method of distribution to every one, it was patented by Dr. Moore and then assigned by him to the public, (letters patents No. 755519, March 22, 1904).

"The nitrogen-fixing power of the bacteria developed by Dr. Moore is so extraordinary that seeds soaked in the solution will sprout and produce luxurious plants in quartz sand which has been previously ignited to a

red heat in order to drive out all nitrates. A simple method of distributing the germs that bring fertility having been found, the announcement was made that the Department of Agriculture was prepared to send applicants free of charge enough inoculating material for several acres. A portion of inoculating material as it is mailed to the farmer consists of three different packages. Package No. 2 contains the cotton with its millions of dried germs. Packages 1 and 3 are the media or food by means of which the farmer can multiply the germs. The department incloses explicit instructions how to use the bacteria. Enough germs are sent in each little package to inoculate seeds for from one to four acres. The package can be carried in your pocket, and yet does more work than several cart-loads of fertilizer. It costs the government less than four cents a cake, or less than a cent an acre, and saves the farmer thirty or forty dollars, which he would have to spend for an equal amount of fertilizer. Different cultures are sent for different crops.

"The results have been surprising. Two patches of hairy vetch, grown side by side under precisely the same conditions, yielded crops as follows: Uninoculated patch, 581 pounds; inoculated patch, 4,501 pounds,—an increase of more than eight times. Crimson clover under similar conditions yielded: Uninoculated, 372 pounds; inoculated, 6,292 pounds,—an increase of nearly twenty times.

"But there are even other wonders that these little nitrogen-fixing bacteria work. It has already been explained how legumes enrich the soil by bringing back nitrogen to it. The same bacteria that increase the harvest of beans or clover or alfalfa tenfold enable the plants to leave many times more nitrogen in the soil than they would have done if uninoculated; in other words, they make the soil many times more fertile, so that the crop of cotton or wheat or corn or potatoes planted next year is many times larger. Cotton planted after an inoculated crop of red clover gave an increased yield of 40 per cent. Potatoes, after an inoculated crop, yielded an increase of 50 per cent. The wheat crop increased by 46 per cent, the oats 300 per cent, and the rye 400 per cent.

"The germs can be used in any climate. It must be clearly understood, however, that only leguminous plants—beans, clover, alfalfa, peas, lupin, vetch, etc.,—are directly benefited by the nitrogen-fixing bacteria. Where the soil is rich in nitrates, the crop is not appreciably increased by the use of the inoculating bacteria; but where the soil is poor, the harvest is increased many times.

"There is not a section of the United States which will not profit by Dr. Moore's discovery. Nearly every state has its worn-out farming-land, bringing despair to the economist who laments our careless handling of the fields and who wonders how the country will support the hundreds of millions soon to be ours. The bacteria mean intensive cultivation with a vengeance, and should give him hope. It is impossible as yet to calculate by how much they will enhance the yield of our crops and of the world's crops, but the results already achieved prove that in time the gain will be enormous." Reported by L. C. N.

THE MISSOURI SOCIETY OF TEACHERS OF MATHEMATICS.

First Annual Meeting.

The first annual meeting of the Missouri Society of Teachers of Mathematics met at Columbia, Missouri, May 6, 1905. A preliminary meeting had been held at St. Louis in connection with the National Educational Association. The temporary organization of the Society was effected at the meeting of the State Teachers' Association at Columbia, December 28, 1904. At a meeting of the mathematics section of that body a committee of organization was appointed, consisting of E. R. Hedrick, University of Missouri, Columbia; H. C. Harvey, State Normal School, Kirksville, and B. T. Chace, Manual Training High School, Kansas City.

The permanent organization was completed at the meeting on May 6. The constitution provides that there shall be at least two meetings each year, one in connection with the annual meeting of the State Teachers' Association, the next meeting of which will be held at Jefferson City, December, 1905, and one during the month of April or May, which shall be the annual meeting for the election of officers and the transaction of general business. The general management of the Society is in the hands of an Executive Council of six members, of which at least one shall be a teacher in some graded school of the state, at least one shall be a teacher in some high school of the state, at least one shall be a teacher in one of the state normal schools at least one shall be a teacher in some college not supported by the state, and at least one shall be a teacher in the State University. On petition of a sufficient number of members the Council will establish divisional meetings. Steps have already been taken towards the establishment of several divisions.

The total membership of the Society is two hundred and twenty-four.

L. D. Ames, of Columbia, presided at the meeting. The following officers were elected: President, H. C. Harvey, Kirksville; Vice-President, L. M. Defoe, Columbia; Secretary, L. D. Ames, Columbia. The members of the Executive Council are E. R. Hedrick, Columbia (chairman); B. T. Chace, Kansas City; B. F. Finkel, Springfield; B. F. Johnston, Cape Girardeau; Wm. Schuyler, St. Louis; Miss E. J. Webster, Kansas City.

The monthly journal, School Science and Mathematics, was made the official organ of the Society, and will be sent free to all members. The annual dues are one dollar and fifty cents.

Arrangements were made to send delegates to a conference to be held in connection with the National Educational Association looking towards the organization of a National society.

The following papers were read:

1. E. Y. Burton, St. Charles Military Academy: "Correlation of Arithmetic, Algebra, Geometry, and Trigonometry."
2. Wm. Schuyler, McKinley High School, St. Louis: "An Experiment in Individual Instruction."
3. Geo. R. Dean, School of Mines, Rolla: "A Method of Teaching Elementary Geometry."

4. J. W. Withers, Yeatman High School, St. Louis: "The Teaching of Mathematics in the High School."

5. F. C. Touton, Central High School, Kansas City: "Some Developments in Elementary Algebra."

6. Wm. A. Luby, Central High School, Kansas City: "The Teaching of Zero and Infinity in the High School."

Abstracts of the papers presented follow below and are numbered to correspond to the titles in the list above:

1. Mr. Burton asked the question, "How shall we bring our pupils to love mathematics for its own sake, to be discoverers for themselves, to look into methods of attack, and to appreciate the elaborate interrelations of propositions, topics and subjects?"

He held that the exclusive use of practical problems, as has been suggested, owing to the limited field of really interesting applications, would result in the loss of much of real cultural value; and that the laboratory method was not generally practicable on account of the length of each session and the necessary increase in the number of instructors. He offered as the solution of the problem the correlation of the various branches of mathematics.

Two methods of correlation were suggested: (1) that of introducing into the subject being studied, parts of each succeeding subject; (2) the studying of the different subjects side by side, an effort being made to bring the subject matter of arithmetic, algebra, geometry and trigonometry into close relation. He would teach mathematics rather than these separate subjects. This paper is the outcome of the successful use of the method for several years in the St. Charles Military Academy.

2. Mr. Schuyler told of an experiment he is at present trying in individual instruction in algebra. He described the methods of conducting classes of over thirty pupils without class recitations or set lessons—each pupil working as rapidly as he can do the work well. As Mr. Schuyler did not think his experiment as yet complete enough, he made no definite statement of results. The work is being continued and will be described in a paper when final conclusions can be drawn.

3. Mr. Dean recommended the use of the inventional method in geometry, along with, and leading up to the demonstrative. He would arouse the pupil's interest and inventive skill, and emphasize the importance of the pupil's gaining clear ideas of the facts and ability to discover facts and principles, rather than of formal rigor in proof. He would present fewer propositions.

4. In the paper presented by Mr. Withers the more important problems at present confronting the high school teachers of mathematics were briefly outlined. For want of time and because the preceding speaker had dealt with geometry, further treatment of the topic was narrowed to the consideration of the teaching of elementary algebra in the high schools.

Every science, the speaker maintained, is an organized system of conceptions so related as to make one's knowledge of the science readily and easily accessible, starting at any point within the system. At the basis of

every such science there is an organizing principle or idea which delimits its subject matter and articulates its parts. In the science of elementary algebra this principle of organization is the equation. The equation is the mathematical sentence or unit of expression. Throughout his whole study of elementary algebra the high school pupil is dealing with the equation directly, or else he is mastering complex expressions which are designed to give him facility later in the handling of equations which involve such expressions. Adequate grasp of this idea gives the teacher proper perspective and determines the proper points of emphasis in the relation of new knowledge to what has already been acquired as his class progresses.

To contribute its just share toward the general training of the high school pupil algebra instruction should aim at much more than merely the solution of problems and the ready handling of difficult algebraic expressions. It should afford training in habits of neatness and accuracy, clearness and correctness of expression and a respect for the laws of right thinking. Free oral and written expression should both be emphasized, since it is by the pupil's own expression solely that the teacher may gain knowledge of the true state of the pupil's mind, and effectively adapt his instruction to the pupil's needs. To this end a form of solution was offered through which the pupil should gradually acquire facility in thinking matematically and in expressing his thought exactly by means of the equation as the mathematical sentence or unit of expression.

5. Mr. Touton emphasized four points: (1) the importance and value of the axiom; (2) the translation of each statement of a written problem into an equation which represents as nearly as possible the exact form of the statement; (3) the introduction and use of the lever in the classroom to demonstrate the truth of an equation and the effect of different operations performed upon it; (4) the introduction of the graph, with the solution of simpler equations by graphic methods.

Concerning the work on graphs, he said that the pupils, without exception, like the work. They are interested to know all the possible applications: to plot incommensurable and imaginary roots; to see that simultaneous equations of the first degree in two unknowns, when plotted, will give straight lines intersecting at but one point, unless they are parallel. In actual class work the students readily solved not only such problems, but also equations of a higher degree graphically, by means of curves which intersect at more than one point. The existence of a greater number of roots in the latter case was especially clear to them. Mr. Touton urged that this work be tested and felt sure that it would be successful in any school.

6. Mr. Luby's paper was a protest against the careless use of the term infinity and the double meaning attached to zero. The discussion of such forms as $^0/_0$, $^a/_0$, etc., would be clearer if a symbol for an *infinitesimal* were used instead of zero. The paper advocated the adoption of such a symbol. In speaking of trigonometric functions it was pointed out that no definition of tan. 90 deg., cot. 0 deg., etc., holds. To call such forms infinite, without further discussion, was to disguise their discontinuity.

Aside from these points the paper criticised the lax use of such statements as "Two parallel lines meet at infinity," or "A straight line *always* cuts a circle in two points," etc. Such statements, unexplained, were characterized as an abuse of English and common sense.

This paper aroused a spirited discussion. Many elementary text-books are extremely illogical in their treatment of these subjects. It was urged that high school students should not be burdened more than necessary with these questions. But it was also pointed out that the term *infinity,* when properly defined, can be used as rigorously as any word in the language, and that it serves a use with which mathemaics cannot afford to dispense.

L. D. AMES, Secretary.

THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS AND ITS LOCAL CENTERS.*

BY W. A. FISKE,
Richmond, Indiana.

It has been said by some one that there is nothing accomplished in life of real worth that is not the result of an intensive interest in something. Of the truth of this statement none can doubt, and it is equally true that the magnitude of this interest is determined in a great measure by the extent of influence the problem has with which we deal. If it is more general in its influence, reaches a greater number of people and is capable of resulting in much good, if our intentions are of a philanthropic nature, it is natural that a keener interest should be manifest in what is done. The influence of *any* undertaking is always made more general, more far-reaching and more enduring by a careful, systematic and judicious organization of all the interests involved.

These principles were recognized when a few years ago the Central Association of Physics Teachers was brought into existence at Chicago, and a reference to the early history of this association will not be out of keeping with the purpose of this paper.

Early in the spring of 1902 a small number of physics teachers in Chicago and near by towns held a meeting with a view to organizing an association of physics teachers of the central states. After a thorough discussion of the matter and the appointment of a committee with power to act, the meeting adjourned. The committee on further consideration called a meeting for the 7th of June. At this meeting more than twice as many schools were represented and the association was finally organized, a constitution adopted and officers elected. The first regular meeting after the adoption of the constitution was held in Chicago during the Thanksgiving recess, November 28 and 29, of the same year. A short time previous to the November meeting it was decided by the mathematical section of the Educational Conference of Acadamies and High Schools to form an association of mathematics teachers to coöperate, if possible, with the Central

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* Read at the April meeting of the Indiana Science Teachers' Association.

Association of Physics Teachers. This resulted, at the Thanksgiving meeting, in the presentation of a petition signed by teachers of mathematics and science, asking that the organization of a larger association be considered; one that would include sections of each of the other sciences and mathematics. The petition was referred to the executive committee, which decided to perfect plans for the larger association. Provision was made for biology, chemistry, earth science, mathematics and physics sections; the Central Association of Physics Teachers becoming the physics section of the larger association. In this manner came into existence the Central Association of Science and Mathematics Teachers.

It is organized and operated along the lines of the American Association for the Advancement of Science, and differs from this asssociation in that it deals with the teaching side of science and mathematics rather than with the side of research and theory.

One of the original ideas of the organizers of this association was the affiliation of all state and local scientific bodies with the Central Association. By this means it was thought that much more efficient work might be accomplished and the ends of the association more quickly reached. Since that time organization of associations and affiliation with the Central Association has been going on at a lively pace. The Northeastern Ohio Association, with headquarters at Cleveland, has a strong and enthusiastic membership. The Eastern Association of Physics Teachers in New England, with a membership of nearly one hundred, is also in line.

It is only a matter of a short time until the Ohio Association of Science and Mathematics Teachers, which already has one hundred members in the Central Association, will organize for affiliation. The work is also going on in St. Louis, in Illinois, Michigan, Wisconsin, and Kentucky, and soon these states will be strongly identified with the Central Association.

Now the question is, will Indiana, which occupies the central position of this great body of states just named, stand idly by and do nothing to lend a helping hand? Indiana has always been in the forefront of educational movements, and it is certainly our duty as science teachers to see that she in no way falls behind now.

The question of our affiliation with the Central Association, however, must necessarily be looked at from a profit and loss basis. First, what are we to lose by such an action on our part? Absolutely nothing. We would elect our same officers from our own science body, likewise our same executive committee, and could hold our annual meetings in the same place or any other part of the state that we might select; or we could discuss any question that we might wish to have come up for our consideration.

On the other hand, what would be our gain?

1. We would receive all the benefits of the larger association.

2. We would be better able to promote and correlate the teaching of science and mathematics by being in direct touch with a larger and more powerful organization.

3. We would be able with less difficulty to bring the young teacher in contact with the older and more experienced ones.

4. We could extend our acquaintance into new and wider fields.

5. We would receive SCHOOL SCIENCE AND MATHEMATICS, the official organ of the association, free of charge.

6. Membership in the Central body would bring to us from time to time, free of charge, special reports, bulletins and circulars of information on subjects of scientific and mathematical value.

7. Affiliation with the Central Association will enable us to suspend the publication of the proceedings of our annual meetings since the valuable papers and the proceedings will be published in the official organ, SCHOOL SCIENCE AND MATHEMATICS. This will do away with raising the money necessary to publish the proceedings ourselves.

8. As to the expense involved, to many of us it will be less than at present, as the subscription to SCHOOL SCIENCE is $2.00 and annual dues in our state association $1.00, making an outlay of $3.00 per year, whereas a membership in the Central Association as an affiliate body would involve an outlay of $2.00 annual dues. This amount would pay for every advantage we receive both from our own center and the Central Association in accordance with provisions laid down in the constitution of the Central body.

Shall we not after this presentation of facts, and a careful consideration of the same, resolve to fall in line with this great movement for a more perfect organization of our scientific interests?

Meetings of New York Physics Club

The thirty-first regular meeting of the New York Physics Club was held at Columbia University on Saturday, March 18, 1905, in the Lecture Room of Fayerweather Hall, with Mr. E. R. Von Nardroff presiding. After the routine business, Dr. Charles Forbes gave demonstrations with the following original pieces of apparatus: (a) The gravity electric time key. By this device the experimenter is able to secure extremely short intervals of time. This is done by placing contact points on opposite sides of the guides along which the time key falls and adjusting them until the intervals desired are secured. By this device the time interval between two separate sounds which the ear distinguishes as one can be measured.

(b) Apparatus for demonstrating the laws of falling bodies. This was an inclined plane mounted at the center so that it could be inclined at different angles for controlling the acceleration. By an arrangement of the track upon which a large marble rolled the distances for 1, 2 and 3 seconds could be shown, also the distances during the first or second or third second and also the velocities at the end of each of these periods.

(c) The Columbia wave machine illustrated in one model the forms of water waves, sound waves and light waves. This could also show the dying out of waves.

President Van Nardroff exhibited and explained a pocket form of the new Piezic Barometer.

Prof. M. I. Pupin, of Columbia University, then gave a very interesting and instructive lecture illustrated by experiments upon Electrical Resonance.

Prof. Pupin also exhibited a new form of a Hewitt lamp, which could be used for charging electric storage batteries.

After luncheon the club adjourned to the Teachers' College, where Prof. Woodhull gave a demonstration of the new Progressive Electric Development outfit and equipment made by Mr. H. T. Evans, of Wausau, Wis. The demonstration was very favorably received by the club, and use of the outfit recommended.

Prof. Woodhull also exhibited the new Reflecting Projectoscope made by A. T. Thompson & Co., Boston, Mass. R. H. Cornish.

The thirty-second regular meeting of the New York Physics Club took the form of the annual dinner. This took place at the Hotel Albert on May 7, and was attended by thirty-five members and invited guests.

President Von Nardroff in his opening speech urged upon the members the desirability of each member's contributing to the club's value by trying new experiments which the members might come across in their reading and then making reports to the club. Mr. Frank Rollins, of the Stuyvesant High School, was introduced, and explained briefly the plans of Commissioner Goodwin with reference to the unification of the work in Physics throughout the State High Schools. Reference was made to the syllabus which Mr. Rollins had been asked to prepare in both Physics and Chemistry It was explained that with regard to the credit for laboratory work in the examinations that either one of three plans might be followed: (1) From the list of 50 exercises, from 35 to 40 would be required in connection with the examination on the text. The note book which contained the record of this work to count as 20 out of a possible 100 credits. This plan would be the recommended course for all and would be followed by probably all the larger high schools in the State. (2). For other schools whose equipment was not so complete, a list of 18 experiments would be accepted, the student offering this smaller number to answer another question from the paper. (3) For those schools which had not yet introduced individual laboratory work no laboratory note book would be demanded, but another question making 10 in all would be demanded from the candidate. This plan comprehends so far as the city of New York is concerned placing the examinations for graduation from High School and admission to the Training School in charge of the Regents department.

Mr. Gilley, of the Chelsea (Mass.) High School, was introduced as the chairman of the Syllabus Revision Committee of the N. E. A. He spoke of the number of attempts now being made in different parts of the country to bring about syllabus revision in the department of Physics. He urged upon the teachers the advisability of instituting a laboratory examination in addition to the examination which had been explained by Mr. Rollins.

Mr. McAndrew, Principal of the Girls' Technical High School, explained in humorous vim his visit to the Keeley Motor and to Mr. Keeley's laboratory in company with reporters of New York papers and a Professor from the University of Pennsylvania. Mr. McAndrew was mystified by what he saw, as was everyone else, until the mystery was explained by the discovery of hidden tubes and an air reservoir and other things which followed the death of Mr. Keeley

Mr. McAndrew deprecated the formation of uniform courses for the whole state, and thought they might do more harm than good.

Mr. Larkins, of the Manual Training High School, Brooklyn, spoke of the desirability of more qualitative work for students in the laboratory, and urged a simplification of the course, which, he thought, was now too scientific, technical and uninteresting.

Prof. Tufts, of Columbia, spoke of the interest taken by the University in the club and of the course to be given in the Summer School this year, especially for the development of the second year work in Physics.

President Von Nardroff brought to the attention of members to the offer of SCHOOL SCIENCE to print the proceedings of the club, to print the more important papers and to furnish fifty copies of the magazine to the club in return for a club subscription of $50. This was unanimously accepted by the club.

Mr. Frank Bryant exhibited a peculiar and interesting form of a hot-water bag intended for domestic use. This article Mr. Bryant had purchased was of rubber, and was filled with a liquid which was cold. The stopper of the bag was unscrewed, and the end of it dried and returned to the bottle, which was then taken up. The liquid immediately became warm, reaching the temperature of 170° F. The warmth of the liquid was retained for 3 hours.

During the intervals between the speeches, Mr. and Mrs. Karl Grienaur, of Brooklyn, rendered some charming musical selections upon the piano and cello, which were very much appreciated by the members of the club. Two of these selections were original compositions of Mr. Grienauer. R. H. CORNISH.

REPORT OF THE THIRD SPRING MEETING OF THE ASSOCIATION OF MATHEMATICAL TEACHERS IN NEW ENGLAND.

The regular spring meeting of the Association was held Saturday, April 15, at the Massachusetts Institute of Technology.

After routine business the subject, "Accuracy in Computation," was introduced by Professor James F. Norris, of Simmons College.

Professor Norris stated that he had been so troubled by weakness in arithmetic on the part of his pupils in chemistry, that he decided to test their knowledge of fractions, common and decimal, and of percentage. The following are some of the questions with sample solutions, given by the students:

Multiply 3/7 by $1\frac{1}{2}$.

Solution: $3/7 \times 1\frac{1}{2} = 6/14 \times 21/14 = 1\,26/14 = 9$.

Divide 4/9 by 4/3.

Solution: $4/9 \div 4/3 = 9/4 \times 4/3 = 27/12 \times 16/12 = 432/12 = 36$.

Subtract 1/4 from 3/6.

Solution: $3/6 - 1/4 = 2/2 = 1$.

Four or five of a class of forty-three failed on each of the above questions. Fifteen failed to find a correct answer for 3% of 81. Twenty could not answer "12 is 3% of what number?" To the question: "If 3 parts in 10,000 of a certain solution are carbon dioxide, what per cent of the solution are carbon dioxide?" One gave the answer, 3 333 1/3 per cent.

Seeking an explanation of these failures, Professor Norris inquired into the grammar school training of his students. He found that the percentage of failure was much less among the students who had studied only the regular grammar school courses, than among those who had studied what might be called extras, algebra, botany, biology, etc. He stated that of course his experiments were too limited in number to be conclusive, but that they at least suggested that grammar school courses may sometimes be "enriched" at the expense of the "R's."

Mr. William J. Drisko, of the Massachusetts Institute of Technology, followed with a paper, "Computation as Affected by Precision of Measurements,"

Mr. Drisko agreed with Professor Norris in regard to the weakness of college students in fractions and percentage. He stated that he found students unable to place the decimal point with certainty, especially when fractions of a per cent were involved. The greater part of Mr. Drisko's paper dealt with short methods of computation in scientific work.

Professor Norris's paper caused an animated discussion led by Mr. Roswell Parish of the Boston Mechanic Arts High School, and Mr. Samuel F. Tower, of the Boston English High School. Some speakers advocated the return of arithmetic to the high school curriculum and expressed the wish that the colleges might restore the formal examination in arithmetic. Others contended that the only solution lay in teaching arithmetic constantly along with algebra and geometry.

It is probable that the Association will investigate the matter at another meeting. WILLIAM A. FRANCIS.

Book Reviews.

The Essentials of Chemistry was published three years ago by Benjamin H. Sanborn & Co., Boston. A revised second edition is now ready for distribution. The authors, John C. Hessler, Ph. D., instructor in chemistry, the University of Chicago, late instructor in chemistry, the Hyde Park (Chicago) High School, and Albert L. Smith, Ph. D., instructor in chemistry, the Englewood High School, Chicago, gave the manuscript a thorough test by using it in actual class-work before sending it to the publisher. The first edition has stood the more try-

ing test of time, and has found increasing favor in the minds of those teachers who have used it. The authors evidently have no new theory in the pedagogy of chemistry to exploit. The book is written after the general plan of the most successful of the older chemistries. Its purpose seems to be to improve upon them, making them more practicable, and avoiding their mistakes; and to introduce modern ideas and theories. The book itself is a good one typographically, and satisfactorily illustrated. Its English, although clear and well expressed, scarcely presents the subject in as interesting a manner as that of one or two books which appeared a number of years ago. The chemistry consists of two parts under one cover, and a third in the form of a pamphlet. The first is the text proper, the second the laboratory manual, and the third a hand-book consisting largely of demonstration experiements for the teacher's use. The text itself discusses the typical elementary gases first, then considers the other most characteristic non-metals, and concludes with the chemistry of the important metals. The descriptive matter is built up around every day experiences to a large extent. It is strong in its presentation of the various applications of chemistry to the technical processes. The laws and theories are introduced naturally through the text; the former, in as far as it is possible, are derived from phenomena already observed and discussed, and the latter are introduced only as explanations of facts previously emphasized. Equations, which are introduced early into the book, are written out in full for some chapters, rather than in symbolic form and are declared at once to express quantitative relations. The chapter on molecular and atomic masses is especially well and simply written. The elementary ideas of physical chemistry are also introduced in an easy and clear manner. Problems and exercises are numerous, and of the kind that develop observation and constructive thought. A very little organic chemistry is given when the element carbon is studied. In connection with such a topic as carbon dioxide, fermentation and alcohol are briefly mentioned; and again under illuminating gas, marsh gas and ethylene are referred to. The new edition, however, includes a chapter at the end of the book, entitled "Carbon Compounds," in which the following topics are considered: Hydrocarbons, alcohols, ethers, aldehydes, organic acids, esters, amines, carbohydrates and phenol derivatives. Many of our teachers believe that brief lessons on these subjects should be given, since a large number of our students will have no further opportunity to study them. Both this chapter and the laboratory experiments covering it are introduced in such a way as to make it possible to assign the matter or omit it, as the teacher sees fit. The laboratory exercises are, to my mind, the strongest feature of the book. At best laboratory work tends to fall into a mechanical performance of the work given by the directions. The authors have avoided this to a great extent by asking a large number of questions; by writing experiments which will give results under ordinary condi-

tions; by requiring simple, inexpensive apparatus, so that each student may have a set; and by giving such explicit directions that the instructor has time to go around among the pupils asking questions and investigating the work. The exercises on the metals in many books are often nothing more than test-tube work. The student sometimes degenerates under their influence. The experiments under the metals in the Essentials offer more variety, and teach in an interesting way more about the chemistry of the subject than any I have ever seen. A number of quantitative experiments, of such a nature as to admit of obtaining results, are included in the exercises. No qualitative analysis, as such, is given. It is a branch of applied science. Tables encourage mechanical work, and this seems to be in direct opposition to the spirit of the book. Some few principles of analysis and the identification of a limited number of substances are suggested. To my mind it would strengthen the chemistry to further emphasize this last point. The examination of substances provides a good means of reviewing their properties in an attractive manner and lays a real foundation for analytical work. As a whole the book is one that has given and will continue to give satisfaction to many who desire to use a high grade text-book. HARRY D. ABELLS,
Morgan Park Academy.

How Nature Study Should Be Taught, by Edward F. Bigelow, A. M., Ph. D. Hinds, Noble & Eldridge, New York City.

Books on nature study are increasing in number at a rapid rate. If this is a sign of a similar increase in interest in nature study, as it probably is, then nature study in the schools must be receiving a well merited impetus. The author of this work has attempted to point out the road to the right sort of nature study. What his conception of the right sort of nature study is, may be judged better by one or two quotations than by anything we may say. He says, "It is nothing less nor more than taking an intelligent interest in the earth and its products." And this, "Nature study is the creating and the increasing of a loving acquaintance with nature."

There is no doubt but that this kind of nature study is what is needed in the schools. There has been a great deal of make-believe nature study, merely marking time with no real interest or love for the work. Such nature study is worse than useless, for it kills what it ought to nourish—the love of nature.

Books like Mr. Bigelow's do a good work, but it seems to us that they ought to do more than this one does. Elementary teachers not only do not know *how* to teach the subject, but they do not know *what* to teach. Books that give practical suggestions and information are in much greater demand than those that tell how. There is a little of this in the present book, but not enough. In short, the book is to be commended for doing well what the author set out to do, but it would have reached a far wider circle of readers and have done much more good if there had been more of practical help for the teacher and somewhat less of talk about *how* nature study should be taught. W. W.

MATHEMATICAL ANNOUNCEMENT AND REQUEST.

On the occasion of the annual meeting of the American Mathematical Society, an informal conference was held in New York, December 30, 1904, at which were present representatives of a number of associations of teachers of mathematics. The following resolutions were adopted:

Resolved: That each association of teachers of mathematics be requested to send three delegates and as many other members as possible to a conference of representatives of all such associations, to be held in Asbury Park at the time of the meeting of the National Educational Association (July 3-7, 1905).

Resolved: That this conference be requested to consider all common interests of the various associations, and in general, such questions connected with the teaching of elementary mathematics in the United States as here follow.

(*a*) As to the desirability and means of effecting closer permanent relations among the associations.

(*b*) As to the desirability and means of organizing a national association or council of teachers of mathematics.

(*c*) As to the establishment and support of a journal devoted to the pedagogy of mathematics.

(*d*) As to the desirability and means of promoting the formation of new associations of teachers of mathematics.

(*e*) As to relations with associations of teachers of natural sciences.

(*f*) As to the desirability and means of establishing relations with the National Educational Association.

Your association is hereby cordially invited to take part in this conference, which will be held under the auspices of the N. E. A., on July 5, at 10:30 in Asbury Park (Parlor of the First Presbyterian Church).

(Signed) ARTHUR SCHULTZE,
Secretary of Preliminary Conference.

The mathematical editor is authorized, urgently, to request all associations of teachers of mathematics of America to send representatives to this conference whether they receive other special invitation than this or not.

G. W. MYERS.

The University of Chicago Press will issue on June 1st a new and enlarged edition of "The Place of Industries in Elementary Education," by Katharine Elizabeth Dopp. This important contribution to educational literature has been greatly enlarged by the addition of a new chapter giving in outline a course in colonial history, and, in addition, the book has been fully illustrated from many original photographs of children actually employed in industrial work. It offers much toward solving the problem of handwork by the grades, and will also determine a new basis or outlook for industrial training in the higher grades.